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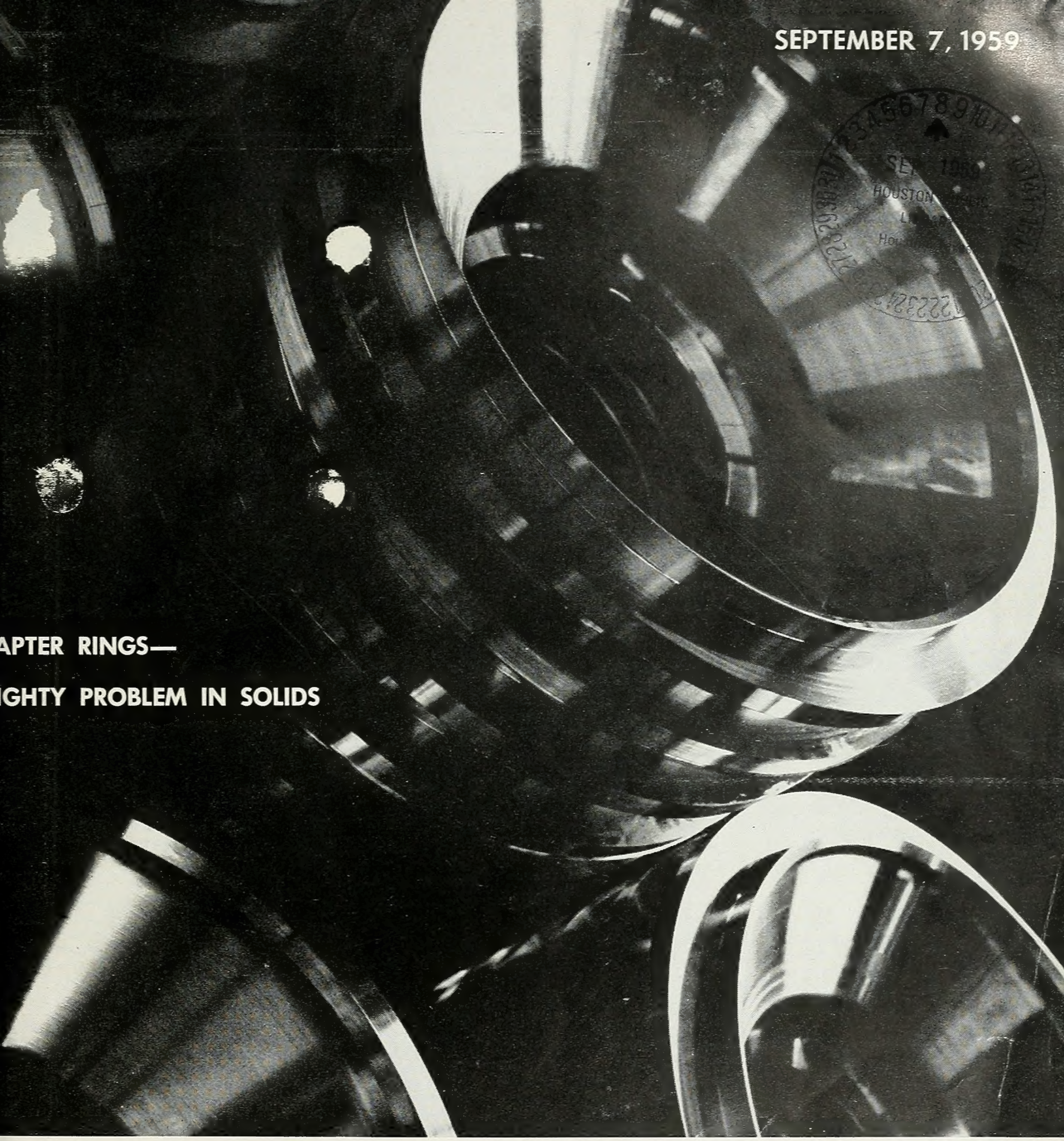

SEP 1959 HOUSTON

APTER RINGS—
IGHTY PROBLEM IN SOLIDS

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Per

ECIAL SECTION

M/R ASTROLOG—an easy-reference status report on all space vehicles and missiles 25

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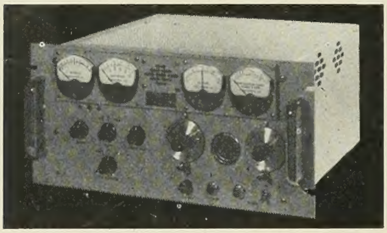

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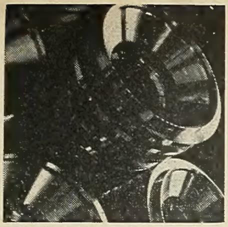
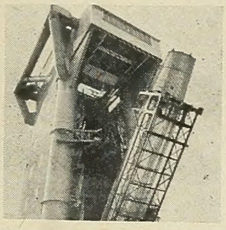
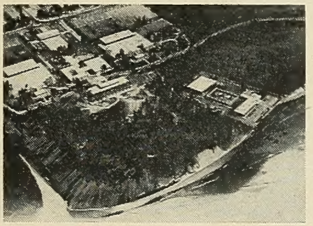


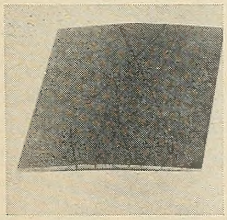
COVER: Adapter rings, or aft closures, like these for *Nike*, along with nozzles are a critical weight problem in solid rockets. But new techniques are providing answers. See p. 13.



BRITISH *Blue Streak* IRBM is being touted by some U.K. scientists as the basic vehicle for a major space effort by that country. This development is reported from London, p. 11.



OVERLOOKING the Pacific in Orange County, Calif., is site for a proposed center to be built by Aeronutronic Div. of Ford. A survey of the county's growth begins on p. 18.



BERYLLIUM sheet formed by extrusion and cross rolling shows highly developed crack pattern after bend ductility test. A report on progress in beryllium R&D starts on p. 22.

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Orange County: Nowhere To Go But Up!
Missile firms have turned the former farming community into the nation's fastest-growing metropolitan area, and the biggest development is yet to come. First of a four-part series on the Los Angeles area 18

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Nozzles Pose Top Weight Problem in Rocket Motors
Today they account for some 30% of a solid motor's dead weight; varied research effort is aimed at reduction 13

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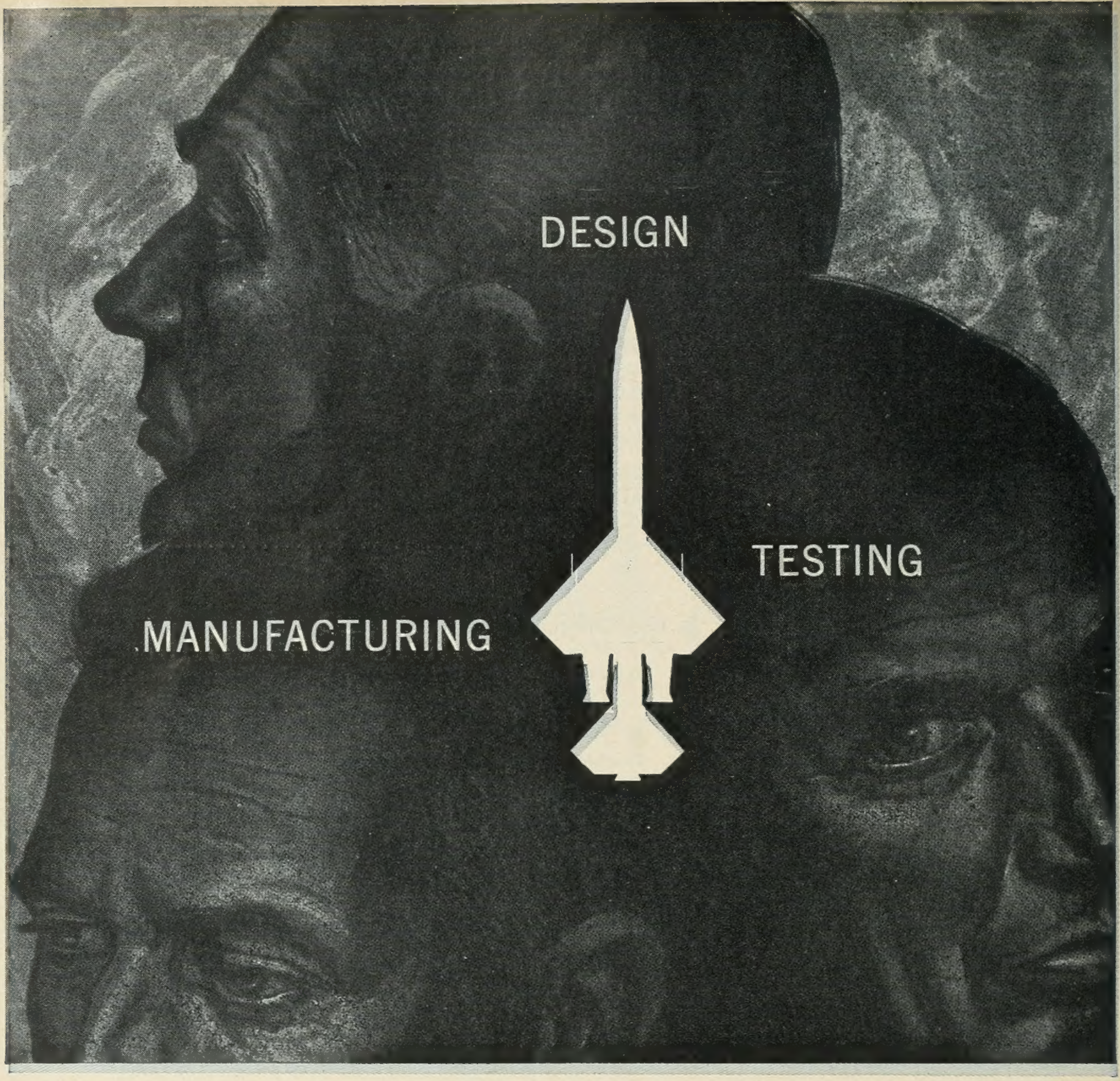

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Washington Countdown

IN THE PENTAGON

A seaborne anti-missile missile . . .

system is seen by Navy officials as a natural for installation on battleships or cruisers. Tentative studies are underway. A prime advantage of seaborne AICBM's would be the interception of oncoming ICBM's over empty oceans rather than population centers.

• • •

The land-based AICBM . . .

Western Electric's *Nike-Zeus*, will undergo future tests over an expanded area at White Sands Missile Range. The range is being spread over an extra 1500 square miles of New Mexican desert to make sure that debris from the tests will fall in uninhabited areas. *Zeus* will be fired only at simulated ICBM's at White Sands.

• • •

Polaris-boosted satellites . . .

are a good possibility within the next few years. The Navy sees **Lockheed's** *Polaris* as an efficient booster for putting 50-pound military payloads into orbit.

• • •

Minuteman repair shop . . .

sites are expected to be picked by the Air Force within the next two months. The repair shops—located at convenient spots around the country—will be used for both assembly of the **Boeing** *Minutemen* and periodic check-up of the birds after they are installed in their hardened bases.

• • •

An October Retirement . . .

for Defense Department Comptroller William J. McNeil is reported to be in the works. Two high-level officials considered top prospects to succeed the head Pentagon money man: DOD Assistant Secretary for Logistics Perkins McGuire, and Air Force Assistant Secretary for Financial Management Lyle S. Garlock.

• • •

Vital ICBM Statistics Dept. . . .

Minuteman will weigh about 75,000 to 80,000 pounds—180,000 pounds less than *Atlas*, 140-,000 pounds less than *Titan*.

ON CAPITOL HILL

Greater unification . . .

of the military services to end missile-space wrangles may well become a political campaign battlecry in Congress by next year. Sen. Clair Engle (D-Calif.) turned up the heat under the issue late last month with his call for one military service. The new, cutting report from the House Military Operations Subcommittee calling for merger of the Army and Air Force brought the issue to a rolling boil.

• • •

Politically-trained ears . . .

opened wide for both Engle's speech and the subcommittee report. Meantime, forthcoming decisions from the Pentagon on Army and other space programs (M/R Aug. 31) could easily make the issue hotter than ever. You can definitely jot this matter down under: To Be Continued.

AT NASA

Air-space sickness . . .

is one of the big problems that NASA engineers have still to lick before the first U.S. astronaut goes into orbit. Some way must be found to stabilize the Project *Mercury* capsule during re-entry. Otherwise, America's first spaceman isn't going to be interested in much besides a paper bag.

• • •

New Nul-G capsules . . .

may be purchased by NASA for testing human reaction to living in a weightless environment for long periods. The capsules—proposed in a design study by **Lockheed**—also might be used for training future astronauts.

• • •

Polar orbit tracking . . .

stations are planned soon by NASA. One will be on the University of Alaska campus. Two more will be in North Dakota and Newfoundland. Rather than build a fourth station in Europe, NASA will share a secret AF station already in existence.

AROUND TOWN

"Smart money" . . .

is being put on the rumor that the Pentagon will lift its ban soon on Gen. Thomas Power's book—"Design for Survival." The SAC commander's book is understood to be a stark warning that the power of America's missile-bomber deterrent forces is deteriorating.

• • •

Some of the reports . . .

that are being passed as "the latest" in the nation's capital:

. . . Russia can be expected to step up building of nuclear-powered submarines capable of launching missiles.

. . . The United States is somewhat closer to development of a truly maneuverable space craft than previously believed.

. . . Military men are urging that Laos be given modern equipment including missiles to meet the current Red invasion.

SHIELD FOR THE BATTLE OF SURVIVAL IN SPACE

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Industry Countdown

MANUFACTURING

One thousand *Polaris* . . .

missiles—or more—may be **Lockheed's** initial production run. It would take 640 just to arm the presently proposed 40 fleet ballistic missile submarines (16 per sub). More will be needed for spares, training and evaluation flights, etc. Any program for launching *Polaris* from surface ships, land or airplanes would jack up the production figure accordingly. Cost-per-bird is estimated at $500,000 —making it potentially a $500 million run.

• • •

Beryllium use in missiles . . .

is increasing. More than 80% of DOD beryllium is going into the missile program. Expected consumption in FY 1960 is 35,000 pounds. In FY 1959 DOD contractors used 12,000 pounds of the lightweight hard-to-work $60-a-pound (refined) metal—5000 pounds in the April-June quarter. (See p. 22 for analysis of structural beryllium.)

• • •

Half the nation's molybdenum . . .

output is being bought by missile builders. Jetavators, liners and nozzles are the principal moly components. It also is in these areas that probably the hottest competition exists between metals and non-metals.

• • •

Anti-friction bearings . . .

are being researched by **Corning Glass.** The company is working with its crystalline ceramic "Pyroceram" to develop bearings capable of operating at temperatures between 1000°F and 1600°F.

• • •

Boost of $20 million . . .

for materials research in FY 1960 has been ordered by Dr. Herbert York, DOD R&E chief. Extra funding, in addition to $50 million already scheduled this year, may be continued in FY 1961 if all goes well. Thermal protection and composite materials are getting $2 million of the new funds.

PROPULSION

Radically new and secret . . .

approach to solid-rocket motor cases is being explored by **Bendix Aviation.** The aim is to achieve strength-to-weight ratio of over 2-million inches under a Navy contract. If the approach proves out, motor case technology (which has yet to reach a 1-million-inch ratio) would leapfrog ahead.

First hot firing of *X-15* . . .

LOX/liquid ammonia engine Aug. 28 proved "exceptionally gratifying" to the Air Force. The **Reaction Motors** XLR-99-RM-1 50,000-thrust rocket was operated at three-quarters throttle for 46 seconds during static test at Edwards AFB. A total of 11 XLR-99's will be delivered to support the *X-15* rocket plane.

• • •

Controlled nuclear pulse . . .

engine for space vehicle has received a $1-million extension from DOD. The *Orion* project initiated a year ago by ARPA is under feasibility study by the **General Dynamics'** John Jay Hopkins Laboratory for Pure and Applied Science, San Diego.

ASTRIONICS

Phone calls via satellites . . .

is a new NASA project called *Echo.* **Bell Telephone Laboratories** is constructing a station that will attempt to bounce signals off of satellite reflectors in the first step of a feasibility study for relaying telephone calls.

• • •

Navy is stacking its space "chips" . . .

heavily on the *Transit* navigational satellite program. Nearly all of the Navy's space R&D is now focused on this project. **Applied Research Laboratory** of Johns Hopkins University is the contractor.

• • •

WE HEAR THAT—

BMD and STL may part . . .

company—at least physically. The BMD would build its own headquarters rather than remain a **Space Technology Laboratory** tenant at Los Angeles. The Air Force is officially denying the report, at present . . . A fabric with better heat resistance properties than stainless steel has been developed by **Raybestos-Manhattan,** Passaic, N.J. It is asbestos based, coated with **du Pont's** new "Viton" synthetic rubber and reinforced with "Inconel" wire . . . NASA is still convinced it will be able to net returning *Mercury* astronauts in the air. Planes have about 30 minutes to get to the capsule after the parachute opens . . . Fewer electron tubes were sold last year. The total of $569 million for power, special purpose and receiving tubes was $16 million less than the previous year—the first significant decline in their history, according to the U.S. Department of Commerce. . . . **Lockheed Aircraft Corp.** will open a new "top-level corporate office" in Paris in addition to maintaining its Geneva office.

More About the Missile Week on page 44

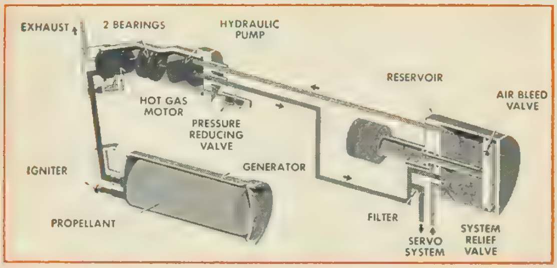
FLIGHT HARDWARE...NOW

VICKERS HOT GAS AUXILIARY POWER SYSTEMS

for missiles and spacecraft

CONCEPT

Vickers piston motors — as used in virtually all existing commercial and military aircraft — are now modified to operate efficiently on propellant-generated hot gas, or bleed gas from the main propulsion system. Minimum weight is achieved by mounting the hot gas motor "shaft-to-shaft" with a Vickers piston hydraulic pump in a common housing. The motorpump, a simple gas generator, hydraulic reservoir, filter, and relief valve are integrally mounted to form a complete Auxiliary Power System in a compact package.



DEVELOPMENT

Production line Vickers hydraulic motors have been operating on hot gas for over 2 years. Units have run on gases as hot as 2300°F without modification.

The present flight hardware was built and tested after an intensive prototype development effort. Test program motorpumps have accumulated over 100 runs each for 1 minute of operation cycle. Since the current development program is aimed at meeting known APS requirements, no limits have been established on the operating cycle duration for this type of equipment.

CONCLUSIONS

Performance and reliability goals for this concept have been met successfully. A complete hot gas APS package in the 2 - 8 horsepower range, shown above, is available within 90 days. Customer specifications for these and larger systems are invited. Write for Bulletin A-5223B.

APPLICATIONS

Because of the increasing scope of APS applications, Vickers conducted a series of studies to establish criteria for APS selection. Recent study results (published in March, 1959) indicate that for short duration operation, hot gas motors offer the best weight advantage in the 1 to 30 hp range. See curve below.

Attractive reliability and early delivery resulting from extensive use of proven hardware may extend the application of these systems to an even greater range of second and third generation missiles and spacecraft. Additional advantages include: low speed equipment (up to 10,000 rpm), convenient ground checkout, growth potential, and no alert time required.

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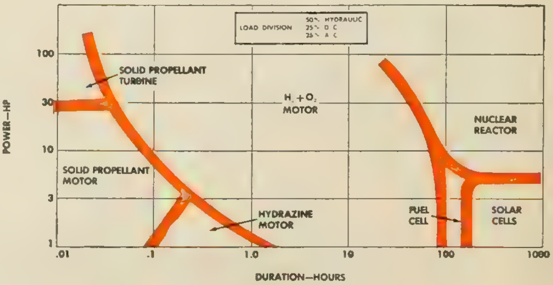

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At Commonwealth Symposium . . .

British Clamor for Major Space Role

But there's mixed reaction to a proposal that Blue Streak and Black Knight be combined in a vehicle to replace the officially-approved NASA Scout

by Donald E. Perry, Managing Editor

LONDON—For the first time—nearly two years after the orbiting of *Sputnik*—the British scientific community, as represented by the powerful British Interplanetary Society, is clamoring for a major space program of its own. The result may be a vigorous competition to eliminate the present "Made in Russia and/or U.S.A." exclusive labels associated with world space experimentation.

Hanging in the balance is the fate of one very important American effort: NASA's *Scout* program abroad. British science now wants to overcome the government's "passive" participation whereby instruments are merely carried into space by means developed *outside* the Commonwealth.

To implement this desire, the U.K.'s *Blue Streak* and *Black Knight* are the touted vehicles. This is contrary to the government's announced policy in May when it signified its desire to use *Scout* as a research vehicle.

Scout, with its prospects of sending a 150-pound payload into orbit, is—many British scientists feel—not good enough. Using *Blue Streak* as the first stage and *Black Knight* as the second, these Britishers envision a 2000-pound useful payload.

The embryo for future British astronautics efforts was formed at the first Commonwealth Space Flight Symposium held recently at Church House, Westminster, here. The Symposium preceded the annual Congress of the International Astronautical Federation.

• **No race suggested**—The tone of the symposium was that the U.K. wants a *major* space program of its own—but not a "race" with the U.S. or U.S.S.R. What is desired is that space exploration be considered as having "no finishing line and an infinite distance to be covered."

The words are those of G.K.C. Pardoe, chief Coordinator of the Ballistic Missiles section of **de Havilland Propellers, Ltd.,** who advocated a space flight program based on *Blue Streak.*

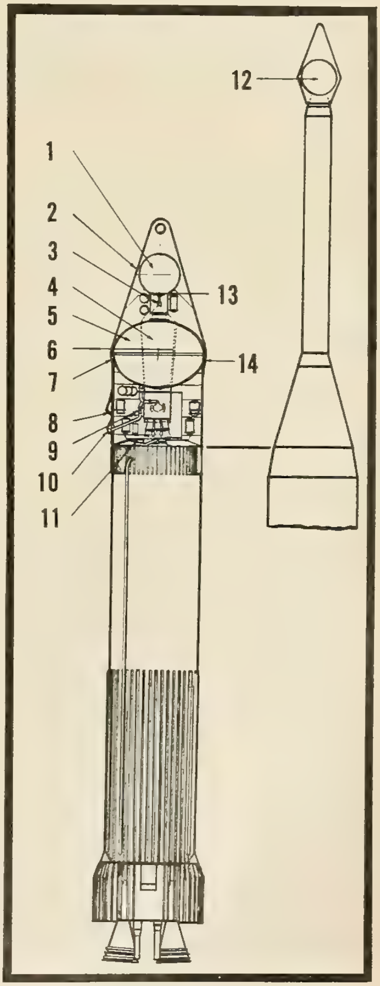
Hitting mildly at U.S./U.S.S.R. policies, Pardoe commented: "The best returns do not always come from the most exciting investments, and by equipping ourselves with a means of moving in terrestrial, cislunar and translunar space, we should be covering the zones of interest . . . of direct value to the earth's inhabitants for many years to come."

The important thing, he said, is to get into space and gain experience in the basic problems involved. The real zone of direct interest for decades to come is between here and the moon, he added.

• **Doubts expressed**—Some observers, including some Britishers, felt, however, that *Blue Streak's* possibilities left something to be desired. Said John E. Allen, head of Aerodynamics, Projects and Assessment Department, **A. V. Roe and Co., Ltd.:**

"(*Blue Streak's*) performance would be becoming obsolescent by the end of the 1960's and a vehicle to succeed it will have to be sought . . . now."

Many U.S. observers pointed out that the guidance flight test of *Blue Streak* is not due for another year at



BRITISH SPACE VEHICLE developed from a modified *Blue Streak* IRBM with the option of using a modified *Black Knight* as the second stage. (See story on page 12.) Specific details include: (1) payload; (2) nose cone; (3) ground connections and release mechanism; (4) kerosene tank; (5) H.T.P. tank; (6) tube through inner tank for electrical and other services; (7) external frame with release mechanism and fairing; (8) electrical ground connectors; (9) second-stage probe separation; (10) ground connectors for propellants; (11) working platform; (12) second-stage payload position; (13) final separation; (14) separation line.

least and that reliability still is an unproven factor. Under present plans, U.S. sources say, there is a schedule of less than a half-dozen flights per year and the U.K. can not hope to achieve maximum reliability under such a minimal firing program.

Be this as it may, existence of *Blue Streak* as a potential main stage vehicle for European countries is a factor not to be discounted. Pardoe commented that nations which do not possess a main stage booster facility could well consider planning space programs using *Blue Streak* because "the design team of the vehicle would be on their doorstep."

But regardless of such "sales pitches," there are many in the British aircraft industry—and in government—who remain to be "sold."

Allen, delivering a paper on "Britain's Place in Interplanetary Exploration," commented that "economic considerations hardly justify an expensive (say £20 million per annum) space programme at the moment." He recommended a "pilot" experiment of two years duration to provide, among other things:

- Creation of a type of Space Flight Research Association.
- Relatively inexpensive hypersonic flight experiments.
- A Commonwealth Spaceflight Year 1960 to stimulate understanding of spaceflight and discuss possible activities.
- Studies for a hypersonic, very-long-range airplane that would be fast enough to be used as a satellite launcher.

The Wedding Would Have Its Problems

LONDON—A substantially unaltered *Blue Streak* missile would give the United Kingdom the capability within two to three years of placing a payload of some 1000 pounds in a 300-mile circular orbit around the earth.

Design considerations for the vehicle were set forth in a paper by G. K. C. Pardoe, Chief Coordinator (Ballistic Missiles), **de Havilland Propellers, Ltd.,** in a paper presented here at the Commonwealth Spaceflight Symposium.

Pardoe recommended use of the Royal Aircraft Establishment's test vehicle—*Black Knight*—as a possible second stage for *Blue Streak* to assure early availability.

Black Knight has a quadruple chamber rocket motor system using H.T.P. and kerosene as propellants. Each of the four chambers produce 4000 pounds of thrust at take-off for a combined thrust of 16,000 pounds. The vehicle's length is some 35 feet and its maximum diameter is 3 feet.

However, use of the long, thin structure on top of *Blue Streak* would dictate careful investigations into the design of the adaptor between the two stages. New dynamic bending loads would be brought to bear on the forward tank section of *Blue Streak*, possibly demanding some structural changes.

Black Knight also would produce different flexural characteristics during first-stage burning which in turn would require some changes in the autopilot system.

Use of a liquid-fuel second stage would, of course, produce the problem of in-flight ignition, but Pardoe believes H.T.P. and kerosene should provide comparatively trouble-free ignition.

With a payload of 1000 pounds the geometry would have to have a low density. The H.T.P. tank has a considerable amount of wetted area which will be directly exposed to kinetic heating during early main-stage boost. To avoid insulation and minimize the input of heat on this wetted area, an attitude control device might be required so that the rear end of the tank faced the sun during coasting phase.

Pardoe said that while there is great merit in using the basic *Blue Knight*, it does fall short of ideal size and thrust characteristics in relation to its main stage.

PROPOSED basic vehicle for a British satellite effort is the *Blue Streak*.

He recommended an alternative: modifying tankage into a "doughnut" configuration. Two hemispherical tank domes would be separated by a parallel section of tank based upon the limiting volume (and therefore weight) which could be lifted by *Blue Streak*.

The same maximum diameter as *Blue Streak* would thus be produced in the second stage to allow for H.T.P./kerosene burning ratio.

Pardoe suggested that the more orthodox lateral separation diaphragm could be replaced by a longitudinal cylindrical-type diaphragm. Kerosene, being the smaller volume, could be contained within this central tube and H.T.P. would be in the outer torroidal container.

Higher pressure would have to be maintained in the kerosene tank to avoid stress on the central tube. However, since pressure in both tanks is relatively small, this should present no problem.

A transition bay in front of the *Blue Streak* tank could contain the inertial guidance system as well as encompassing the *Black Knight* propulsion bay. Small ancillary rockets would be required in the second stage.

The short configuration of the launch vehicle would involve few changes to its servicing tower, thus cutting down development costs.

• **Three choices**—Pardoe's proposal for producing a space vehicle embraces three areas. The first approach—simple but with limited capability—would be to use a solid rocket system as the second stage to place, say, 1000 pounds in a 300-mile orbit. On the other extreme would be a more elaborate liquid propulsion second stage, based on existing equipment, which would be able to place a payload of some 2000-pounds in a 300-mile orbit. Between the two measures is a half-way stage where *Black Knight* in its present form and immediate availability could put about 1000-pounds in a 300-mile orbit.

The British have contracted for three NASA *Scout* vehicles. *Scout* has a capability of placing about 150-pounds in space.

Soviets Announce They'll Attend IAF Congress

LONDON—Russia will be represented by at least a token delegation when IAF Congress meets here this week.

IAF officials received a surprise cable indicating that Prof. Leonid Sedov and Prof. Kyril Ogorodni would attend, possibly accompanied by one more delegate.

Nozzles are Top Weight Problem

Today they comprise some 30% of a rocket's dead weight, but the outlook for reduction appears favorable through various industry efforts

WASHINGTON—Rocketry in some respects is just one series of problems after another. Solve one, and another rears its head to challenge any further progress.

So it is with solid rocket motor cases. For months the big problem has been how to crack the notch sensitivity barrier and come up with a development series of rocket motor cases whose cylindrical walls had a minimum yield strength of 220,000 pounds per square inch or more (see M/R series, June 8, 22).

Now it looks as though this is about to be achieved—and all of a sudden something else takes over as the limiting factor on improving mass ratios. Now, nozzles are the number one weight problem in motor cases, with forward bulkheads and aft closures with their heavy thickened sections running a close second.

Weight reduction in the cylindrical section of the case itself is still important, but the potential there for improving mass ratios is far less than it is in other areas. And as always in this business, the customer is willing to pay for the answers he wants; more and more money is going into R&D in these areas.

Current mass ratios—propellant weight to total powerplant weight—range from 0.85 to a little over 0.90 in very exceptional cases—up from less than 0.80 during World War II. For a comparison with some kind of theoretical maximum, check these figures by Dr. Hal Ritchey, vice-president, **Thiokol Chemical Corp.**:

• **Desired ratios**—For that can of beer he wants to place on the moon, Dr. Ritchey has calculated a mass ratio of 0.814; for an egg (in the shell), 0.896; a candy bar, 0.956; and a packaged loaf of bread, 0.977. Actually, when you compare current rocket mass ratios with these figures, we're not doing badly.

Improvement in mass ratios since World War II has been due to two fairly elementary technologies:

—development of inside-out propellant burning techniques which cut temperature problems of motor cases to a minimum.

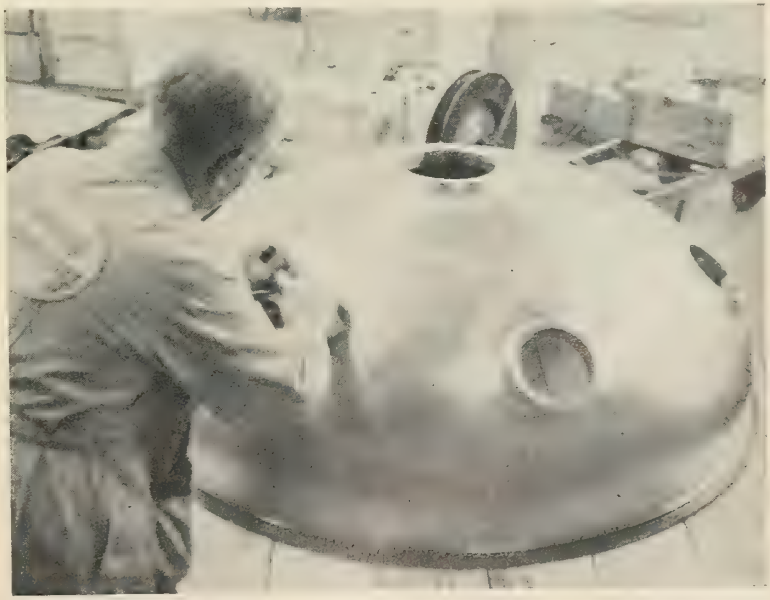
—creditable progress in development of high-strength, thin-wall metal motor cases and in low-density (plastic/glass) materials.

Though still far short of present goals, motor case technologies are approaching a point of diminishing returns. This isn't to say solid rocket makers have lost interest in a 240,000-psi minimum-yield strength steel motor case, for example. Far from it. Millions of dollars are still pouring into the effort to beat notch sensitivity and reach that elusive goal—and with some degree of success. There are programs under way that strive to attain 500,000-psi min-yield in the cylindrical part of a steel case; 200,000 psi in a plastic case.

• **Deadweight**—However, in all the sweat over cylinder wall improvement, other vital (and heavy) solid-rocket motor parts have been largely ignored—such things as the forward bulkhead, aft closure and nozzle. For example, in today's typical medium-size solid-rocket motor, of the four main components which make up all that dead weight, the motor case (the cylindrical section) may account for 20%; the forward bulkhead, 30%; aft closure, 20%; and nozzle, 30%.

This is for a rocket with a length-to-diameter ratio of about 2.5. Increase the ratio, and weight of the cylindrical section goes up proportionately.

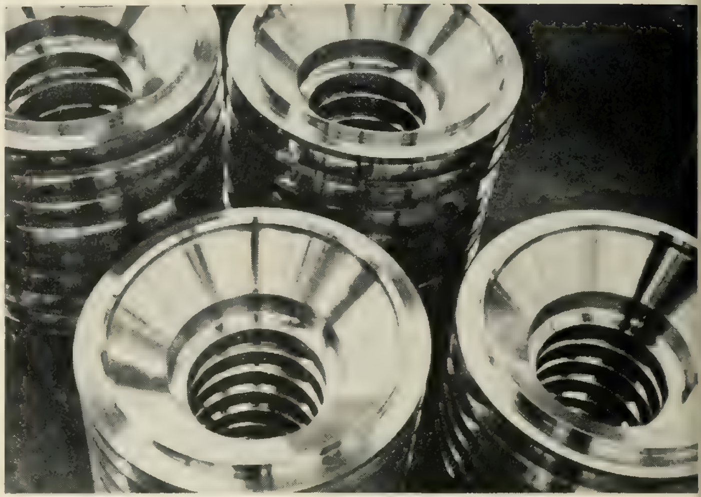
Suppose our typical rocket motor has a mass ratio of 0.90 and that its



THOUGH the wall thickness of this forward bulkhead for a large solid-propellant rocket motor gets as low as .070 in., thickened sections boost the total weight.

nozzle approaches are varied and promising . . .

MUCH OF the weight of rocket motors is represented by wing attachments and thrust elements with thick sections.



FINISH-MACHINED adapter rings for *Nike* booster case show how thick the metal can get. The aft closure represents one-fifth of the weight of a typical rocket motor.

cylindrical section has a min-yield strength of 200,000 psi. Even if we increase that strength level to 400,000 psi (a prodigious feat with current technologies), we only run our mass ratio up to 0.91.

However, if we can improve the performance-to-weight ratio of the other three factors by the same relative amount—2-to-1—mass ratio jumps to 0.94 without any improvement in actual case strength.

And it is in these areas that the coming bulk of solid-rocket motor case improvement is beginning to be concentrated.

- **Heavy fittings**—In forward bulkheads and aft closures, the main problem is the weight of fitments, bosses, etc. For example, some large solid-propellant motors have forward bulkheads fitted with a series of thrust reversal nozzles. Even though the basic wall thickness may be 0.070″ or less (well into the 200,000-psi range), bosses for fitting nozzles may be 0.75″ on their thinnest dimension, with the case wall around them tapering gradually down to the basic dimension.

In addition, the bulkhead itself must be attached to the case. If this is done by weldment, there's no material increase in weight in this area. But as often as not it's done with bolts, breechlocks, etc.—all of which require thickened (thus, heavier) sections. And these thickened sections may weigh more than all the rest of the forward dome.

With few exceptions, propellants are cast into solid-rocket cases before attachment of forward closure and/or nozzle; whatever remains to be fitted after the propellant is cast and the core mold withdrawn must be attached by some means other than welding. Heat of welding would be too likely to set off the propellants. Again, this means bolts, threads, breechlocks, keylocks, ringlocks—and inevitably a thicker, heavier section.

- **Peculiar nozzle problems**—The nozzle falls into a trouble-making realm of its own. Not only must it usually be fitted by similar means, but it suffers from a special set of environmental problems. A rocket exhaust is a high-temperature, high-velocity, highly abrasive and highly erosive flow; nozzles must be resistant to heat and/or provide a heat sink and must be physically and chemically tough to retain their critical geometry until burn-out. For these reasons, they are the heaviest part of a rocket motor for the volume they displace.

- **Plastic headaches**—Only in plastic motor cases have fitment and attaching problems been reduced to a near-minimum. The case, forward bulkhead and aft closure are made in a single operation, resulting in a one-piece motor. Metal attaching rings (usually aluminum) for nozzles and igniters are inserted in the plastic structure during fabrication. Even here there's room for improvement—such as reduction in attachment ring size and weight. And of course the same old nozzle problem remains. Some highly specialized rocket motor cases have 85% of their weight concentrated in the nozzle. Others, utilizing molybdenum nozzles, run the ratio up even higher.

Another headache with plastic motor cases made in a single unit is that casting fixtures must be inserted in pieces and assembled inside the case, then disassembled and withdrawn one-by-one after propellant casting. Though there's a weight saving in cases made this way, cost and complexity of propellant casting operations are substantially increased.

- **Solution still lacking**—The problem of attaching the various metal parts of a motor case to one another is an old one; but no one has yet provided a solution that is both reliable and lightweight. Bolted sections have been largely abandoned as unnecessarily heavy. The trend, where possible, is to weld—though reliability of production welding is still something of a problem. Welding is sometimes—but not always—possible with both the forward bulkhead and the aft closure, the nozzle attachment ring usually being large enough for most casting operations.

Another approach to both forward dome and aft closure attachment in metal cases is to spin or deep draw the case, including end closures, in two pieces; then to put them together at the middle with a circumferential weld; and finally to machine igniter boss and nozzle attachment ring out of sections left thick during drawing or spinning.

None of these systems, including threads, breech, ring and keylock systems, has so far proved very satisfactory. All are heavy and sometimes cause trouble when attempts are made to undo them—as may be necessary for disassembly for such purposes as propellant casting or later inspection of the propellant grain.

Anyone with a good, lightweight solution to this attachment problem can find a ready market for a development contract with any one of the many government agencies concerned with solid propellant rockets or the companies that manufacture them.

- **Nozzles promising**—Chances of reducing nozzle weight are better. Approaches to this problem are many and varied, ranging from techniques for electroplating any electroplatable metal to such unlikely materials as paper, wood and plastic, to the recrystallization of silicon carbide on graphite.

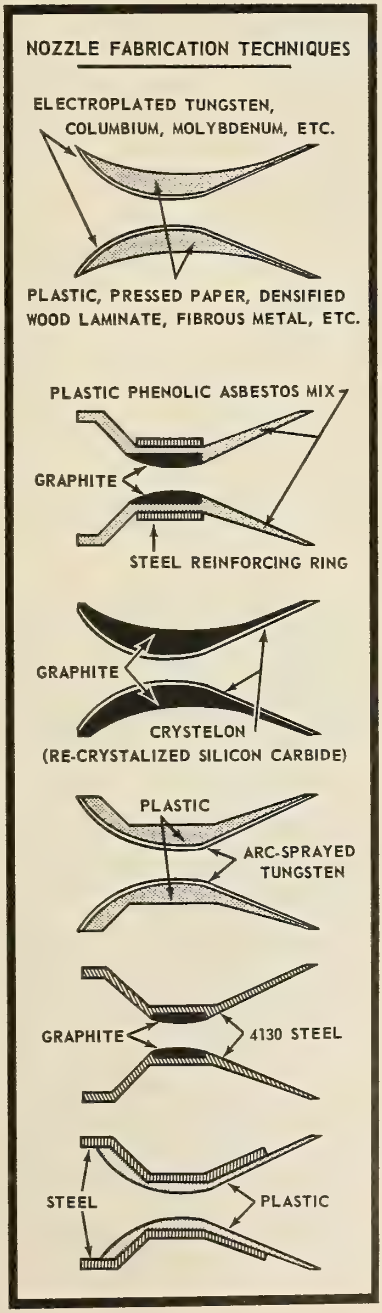
Thin metal sections by themselves do not offer the same advantages in nozzles that they do in motor cases. Under the rigors of rocket exhaust, they lack dimensional stability. But, more importantly, they have no ability to withstand the heat involved—either to absorb it in a heat sink or simply to stand up and take it. Possible exceptions are some of the refractory metals—of which molybdenum is one. However, moly's high density (over 12 times that of steel) makes it a poor candidate for a lightweight structure.

Non-metallics, however, are beginning to show real promise of nozzle weight-reduction. For example, a thrust-vectored nozzle made of molybdenum weighs something over 350 pounds, compared to less than 50 pounds for a comparable nozzle made of plastic and steel. Plastics not only have dimensional stability due to their bulk, but demonstrate very favorable characteristics in the presence of high-speed, high-temperature gas flow.

Currently, the most popular approach involves the use of phenollic-glass-asbestos-etc. aggregates which are first pressed into their general shape and then finish-machined to tolerance much in the manner that metal is machined. These are usually backed up by metal (4130 steel, for example), but the total weight is less than it would be for an all-metal nozzle with, perhaps, a graphite insert.

- **Other approaches**—One of the more successful current efforts in nozzle weight reduction lies in refractory coated graphite. **The Norton Company,** for example, machines a nozzle out of pure graphite and then vaporizes and sprays a thin coat of silicon carbide on the inner contours of the throat. This is then placed in a high-temperature furnace where silicon carbide reforms into minute crystals—smooth and as hard as a carbide cutting tool. The problem with this nozzle is strength; efforts are under way to wind it with narrow metal reinforcing strip. Other companies are conducting similar work.

Yet another approach to the nozzle problem comes out of **General Electric Company's** Rocket Engine Section where efforts are being made to find a suitable plastic nozzle material that can be arc-sprayed with a tungsten liner.


NOZZLE FABRICATION TECHNIQUES
ELECTROPLATED TUNGSTEN, COLUMBIUM, MOLYBDENUM, ETC.
PLASTIC, PRESSED PAPER, DENSIFIED WOOD LAMINATE, FIBROUS METAL, ETC.
PLASTIC PHENOLIC ASBESTOS MIX
GRAPHITE
STEEL REINFORCING RING
GRAPHITE
CRYSTELON
(RE-CRYSTALIZED SILICON CARBIDE)
PLASTIC
ARC-SPRAYED TUNGSTEN
GRAPHITE
4130 STEEL
STEEL
PLASTIC

Ethyl Corporation's method for electroplating heretofore unplatable materials is new and has not yet been fully investigated. However, this, like plasma spraying, opens up a whole new range of possible basic nozzle structure materials.

Still other areas that offer a longer-term potential include fiber metallurgy where very thin (.0001" diameter) metal fibers are pressed into the desired shape and then resistance welded so that everywhere a fiber touches another, it is joined by a weld. A great variety of densities and strengths is possible with this method. Although it usually results in a porous material, this drawback can be overcome.

Another field, of course, is ceramics. Efforts right now are being made to combine ceramics with other materials, much as glass is combined with plastic in monofilament winding. Work on the development of ductile ceramics has made considerable progress recently and this may offer one of the better long-term solutions.

Better Method Developed To Measure Solid Changes

MENLO PARK, CALIF.—Scientists at the **Stanford Research Institute** have announced the development of an improved method of measuring creep and stress relaxation in solid propellants.

The research team of R. B. Beyer, C. F. Clark and B. C. Belt said last week they expect the new process to add significantly to knowledge of solid propellant aging.

The method reduces the observation time from two weeks to one day, and is accurate to 0.005 inch. Another advantage pointed out by the researchers is the determination possible at the initial portion of the test.

A more accurate distinction thus is made between the reversible elastic properties of the material and its irreversible creep formation.

A unique apparatus measures the stress relaxation by mechanically introducing an initial deformation. The stress decay is then measured and recorded automatically.

The project is sponsored by the Air Force's Wright Air Development Center and is chiefly concerned with the changes in solid rocket propellants during storing and aging.

Double-base Solids Still Standard Despite Inroads by Polyurethane

by Jay Holmes

INDIAN HEAD, MD.—Although *Polaris* and some other missiles use the new polyurethane binder, double-base composition is still the standard for a major part of America's solid-fuel program.

At the Naval Propellant Plant in this Potomac River community, the Navy's "in-house" staff manufactures double-base grains for almost all of the solid-fuel rockets used by the sea service—and a few for the other services.

Relatively small rockets use extruded and machined double-base grains. But the only safe method of making larger grains—such as the 3000-pound grain, the largest made here—is by casting.

There is still a chance the big *Polaris* grain may switch to double-base. Two years ago, when the Navy chose polyurethane, case bonding of double-base grains was a problem. Now that has been solved. NPP announced last December it is working with **Allegheny Ballistics Laboratory,** Cumberland, Md., on a double-base propellant for possible *Polaris* use. The experimental fuel is now in pilot-plant production and has undergone preliminary testing.

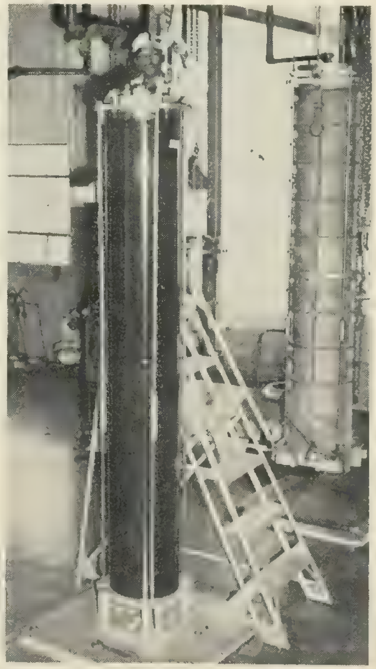
Double-base grains extruded here include those of the *Sidewinder* and *Zuni* and gas-generator propellants for *Sidewinder, Sparrow* and the Army's *Hawk.* Among the cast grains produced at Indian Head are those for the *Talos, Terrier, Weapon A, Boar* and *Bullpup.*

• **The process**—Recently, the Defense Department declassified the details of the grain casting process at Indian Head. Capt. G. T. Atkins, Commanding officer, outlined the operation for a visitor:

The grain normally is cast inside an inert plastic beaker—or inhibitor—which prevents the burning of the propellant on the outer circumferential surface. In the mold-assembly operation, the beaker is placed inside a tight-fitting corset of metal alloy or glass fiber. Cores are positioned longitudinally through the inhibitor and held in place with plates at either end. The cores form the perforations in the grain, which determine the amount of internal burning surface.

Casting powder then is poured into the assembled mold. The powder consists mainly of either nitrocellulose or nitrocellulose with some nitroglycerin. It is in the form of small, solid cylindrical granules about the size of a thin pencil lead in length and diameter. The powder is poured into the mold from overhead bins.

After auxiliary parts of the mold assembly are put into place, the mold is evacuated for about a day. This reduces total volatiles and excess moisture—which would decrease the coalescent properties of the mixture. Evacuation also reduces the moisture content of the casting solvent.



WORKER PREPARES to remove cores from cast solid grain at Indian Head plant.

• **Pressure differential**—The solvent—usually nitroglycerin with a small percentage of plasticizer and stabilizer, is introduced into the mold through one of the end plates. Air pressure forces the solvent through a tightly packed column of powder. The casting operation is complete when it reaches the opposite end.

The temperature must be kept very close to 70°F while the solvent is being introduced. If it varies too much, casting becomes very difficult. When temperature is too high, the cast powder will tend to gel too rapidly. When temperature is too low, the viscosity of the solvent becomes too high to permit it to move freely through the casting-powder granules.

The powder grain in the mold must be cured for several days at temperatures usually ranging from 100° to 200°F. During this period, the powder is transformed from a sticky mass into a solid plastic grain. After curing, the mold is removed to a rest house where it remains at room temperature for about 24 hours or until it reaches ambient temperature.

The grain is placed in a special hold-down stand while the core is being pulled from the mold after the mold parts are removed. The core, in either horizontal or vertical position, is normally removed easily, but it may need a slight initial shove. A plastic coating may lubricate the surface and make this easier.

Next the grain is cut to specified length and the ends are squared. For safety, this is done by remote control, with the operator watching the operation through a heavy glass window. During the cutting operation, water usually is played on the saw blades to reduce the hazards of excess friction.

If the grain meets the requirements of a thorough and rigid inspection, it is accepted for loading in a missile motor.

SPACE RESEARCH

BRISTOL SIDDELEY GAMMA ROCKET ENGINE POWERS BLACK KNIGHT-BRITAIN'S HIGHLY SUCCESSFUL SPACE RESEARCH VEHICLE

On 11th June, 19,000 lb of thrust sent Black Knight to the threshold of outer space—500 miles above the Woomera rocket range in Australia.

This was the third successful firing *(there have been no failures)* and much of the credit for Black Knight's trouble-free performance must be given to the Gamma.

The Bristol Siddeley Gamma 201 is a liquid propellant rocket engine. Four trunnion-mounted chambers burn kerosene with HTP and each chamber is fed by its own turbopump unit. The complete weight of the engine compartment is less than 700 lb (dry) and Gamma delivers 19,000 lb at altitude—16,400 lb at sea level.

Black Knight is a research vehicle and no military applications are planned. But the experience gained and lessons learned from this highly successful space probe will be invaluable in the development of Britain's IRBM—Blue Streak.

So impressive is Black Knight's performance with the Gamma powerplant that even more advanced applications are being actively developed. In fact, Black Knight coupled with Blue Streak is first choice to put Britain's projected space satellite into orbit.

BS

BRISTOL SIDDELEY ENGINES LIMITED

First of a Series

Orange County: Nowhere To Go But Up!

Missile firms have turned the former farming community into the nation's fastest-growing metropolitan area—and this is only the beginning

by Frank G. McGuire

LOS ANGELES—Discover Orange County! is the advice given in the county's Industrial News Directory, and a great many firms in the missile industry have done just that.

Orange County, the fastest-growing metropolitan area in the nation, had 6000 jobs in manufacturing employment in 1950—today it has 40,000. Lying between Los Angeles and San Diego Counties in Southern California, Orange County seems a cinch to catch most of the overflow of expansion from firms in those two heavily industrialized areas, but mostly from Los Angeles.

Over 160 miles of high-speed freeways criss-cross the county, and a number of airports serve it, including the large commercial airports of Los Angeles and San Diego. The state is planning a considerable expansion of the freeway network in the county.

The firms now located, or building, in Orange County read like a Who's Who of the missile industry:

Lockheed Electronics and Avionics Division (LEAD) is preparing to build a permanent headquarters facility on a 200-acre site in Newport Beach.

Autonetics Division of **North American Aviation** is a newcomer, with a 370-employe facility handling computer operations and engineering work on inertial navigation systems in Fullerton.

Aeronutronic Division of **Ford Motor Co.** is in various stages of construction and utilization of its group of buildings at Newport Beach.

Hughes Products Group also has a new home in Newport Beach for its Semiconductor Division, and turns out subminiature devices here. The entire research and manufacturing activities were moved from Los Angeles. Another Hughes unit, in Costa Mesa, turns out silicon and germanium diodes.

Hughes Ground Systems Group is another of the missile-industry entities moving into Orange County. Growing from 800 employes in 1957 to 5000 now, the group has recently occupied a brand-new plant of 850,000 square feet in Fullerton, housing administration, engineering and light electronic assembly operations.

Thompson Ramo Wooldridge has a $2 million component plant under construction for its Tapco Group. Scheduled for completion in February, the three-story plant in Anaheim will assume most of the Bell and Long Beach operations of TRW.

Interstate Engineering Corp., of Anaheim, has an entire "family" of firms in broadly diversified fields, and is heavily involved in the missile program.

Cannon Electric Company recently passed the 500-employe mark in expanding its new plant in Santa Ana. The ten-month-old plant produces Cannon's most competitive line—its military standard hardware.

• **Why Orange County?**—As is obvious from the list of firms involved, the growth in Orange County is largely in the electronics field. In past years, there has been a "latent resistance" againt the influx of industry to Orange County, mostly because of the disadvantages associated with "heavy" industry such as steel mills. It has apparently come as an awakening that it is possible to have the economic advantages of industry without the disadvantages—unsightly huge plants, smoke, heavy truck traffic, etc.

Much of the change in attitude is due to the campus-type architecture used in construction, and the research and development nature of many of the firms now going into the county. Even those producing considerable quantities of goods are doing so in attractive buildings, without the smokestacks, railroads criss-crossing streets, and other blemishes that the old-time residents associated with industry.

W. Worth Bernard, publisher of the *Orange County Industrial News,* says the county hopes to have enough industry to support an anticipated population of 2½ million by 1980. A study by **Stanford Research Institute** indicated this was in store, and some feel that the two-million mark may be reached by 1970. Today's population is 680,000; in 1950, it was 216,000.

B. F. Coggan, Vice President and Division Manager of **Convair-San Diego,** said: "This area (Southern California) is becoming the fountainhead of scientific manpower. The scientists are being brought here, not by the handful, but by the hundreds! . . . Because of this, the industrial growth of Orange County will be terrific." With its thousands of scientists qualified for teaching, the county has been suggested as the site for a Science Academy paralleling, in science, Annapolis, West Point and the Air Academy.

• **Beethoven and boats**—Recreational and other benefits of the area are numerous: three symphony orchestras, 12 golf courses, 14 bowling centers, Disneyland, Knott's Berry Farm, and the greatest small-craft harbor in the nation (last year, more boats were sold in California than new cars!).

The future may see three colleges serving the county. Chapman College in Orange, the new Orange County State College now being built in Fullerton, and possibly a county branch of the University of California, still in the works. The county has 18 high schools, increasing to 22 by the fall semester, and three junior colleges.

A detailed economic study of the county was undertaken by Stanford Research Institute at the request of the County Board of Supervisors, to guide planning in highway construction, flood control, recreation, airport planning, industrial development, and zoning.

The amount of land zoned for industry, or in the process of being zoned, is upwards of 45,000 acres in the county. Although some feel this is too much, it is estimated that such an amount will be needed to support industry for a 2½ million population.

In addition to those listed previously, a great number of firms have facilities in the county: **Giannini, Burroughs, BJ Electronics, Hallamore, General Electric, Interstate Engineering, A. O. Smith, Beckman Instruments Narmco, Electronic Engineering Co., Pacific Scientific Aeroproducts, U.S. Borax and Chemical Co., Pacific Laminates,** and numerous others.

Lockheed's facility will be one of the larger new ones. The site is a 200-acre tract close to the Orange County Airport, where construction will begin before the end of the year. Occupancy is expected by late next summer. The new plant facilities will have a capacity of up to 1000 research, engineering and administrative personnel and supporting groups. For the foreseeable future, LEAD expects to keep its temporary facilities as a manufacturing plant.

Until the new structure is ready, LEAD is gradually developing its new position by staffing the key administrative positions, and bringing in the necessary technical and scientific personnel. Concurrently, it is moving along with sale and development of its product line, which will be all military at first, then branch out into specialized industrial areas. LEAD expects to have about 400 employes by year-end, compared with 75 now.

Autonetics Division of North American Aviation (which has just built a 200,000-square-foot building in Downey) employs 370 people at its Fullerton flight control engineering department. The facility, which houses an analog computer installation for work on flight control problems, may be expanded even further by the addition of leased space. There are no plans afoot as of now to move any Autonetics operations outside the LA area.

Cannon Electric Company, with plants in Salem, Mass., and Phoenix, Ariz., has housed its production facilities for the military standard line to the Santa Ana plant in Orange County. The company's most competitive line, military standard plugs, are not specifically designed for missile use, but are used when standard equipment shows up in a missile system.

Built in October, 1958, the plant has a capacity of 750 employes, but still is not considered by the firm to be a significant move away from the Los Angeles area, since most of the company's eighteen product lines still come out of the Los Angeles headquarters group. Two lines are handled by Salem and two by Phoenix: the Guided Missile and Special Products lines are handled at Phoenix because it lies in different procurement area.

Most of the new space being utilized by Cannon is for manufacturing, but each facility has its own engineering section. Relative to the headquarters group, the newer facilities are small: Los Angeles, 340,000 square feet; Phoenix, 70,000, and Santa Ana, 112,000. The Los Angeles HQ group is spread throughout eight buildings occupying several city blocks, and one company spokesman told M/R that "we'd like to tear them all down and rebuild our facilities under one roof." Nevertheless, there are no plans for ever removing the executive offices out of Los Angeles.

The company recently bought a new building in Orange County that had been built by a die-casting company, but never occupied. Although it is now being used mostly for storage, Cannon believes it is the only die-casting facility in the county.

Aeronutronic Division of Ford, similarly to LEAD, is occupying a 200-acre site in Newport Beach. The division's $22-million research and engineering center, designed by **Wm. L. Pereira & Associates,** overlooks the Pacific Ocean, and consists of an ultra-modern 120,000-square-foot computer electronics facility which was occupied in July, a Space Technology Building of 120,000 square feet scheduled for completion by Jan. 1, and a Central Services Building scheduled for completion during the first quarter of 1960.

A 30,000-square-foot Environmental Test and Reproduction Building will be built by November, 1960, and a multi-story administration and a Tactical Weapon Systems Operations building are both scheduled for completion by mid-1960.

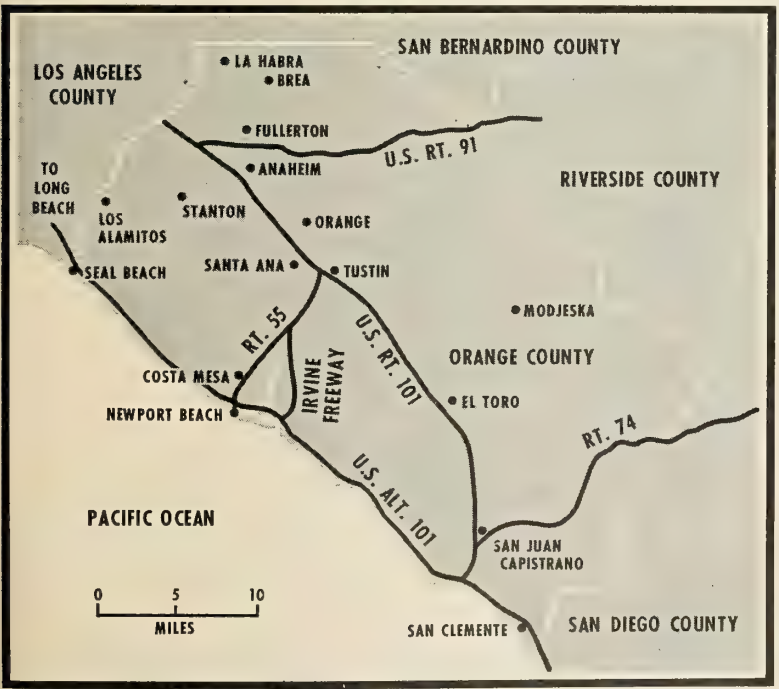
Beckman Instruments Systems Division in Anaheim handles assembly of the electronic data processing systems used in developmental testing of rocket engines. One of five Beckman divisions in Orange County, the Systems division also has a plant in Richmond, Calif.

Interstate Engineering Corp., (with a number of sub-organizations), produces missile and aircraft components, as well as instrumentation, in Orange County. A Navy prime contractor, **Interstate Electronics Corp.** produced instrumentation for the *Polaris* FBM system, including three instrumentation systems for the Atlantic Missile Range, and instrumentation for the USS Observation Island. Latter equipment includes photo apparatus, television, and electronic ranging gear.

Interstate Electronics, a subsidiary of Interstate Engineering, is also at work on development of a complete system for underwater firings from nuclear subs. Interstate Electronics has a staff of over 350 employes, with 70 of them engineers.

Supplementing and supporting the many companies listed here are dozens of small contractors and their plants in the county.

In the entire industry-laden area of Southern California, the prime location for just about any industrially "clean" industry appears to be Orange County, and things will probably remain this way for some time to come.



A LITTLE-KNOWN agricultural section as recently as 1950, Orange County today has a population of 680,000 and anticipates some 2½ million in another 20 years.

Clary introduces a new concept in valve design...

top-performing economical regulators

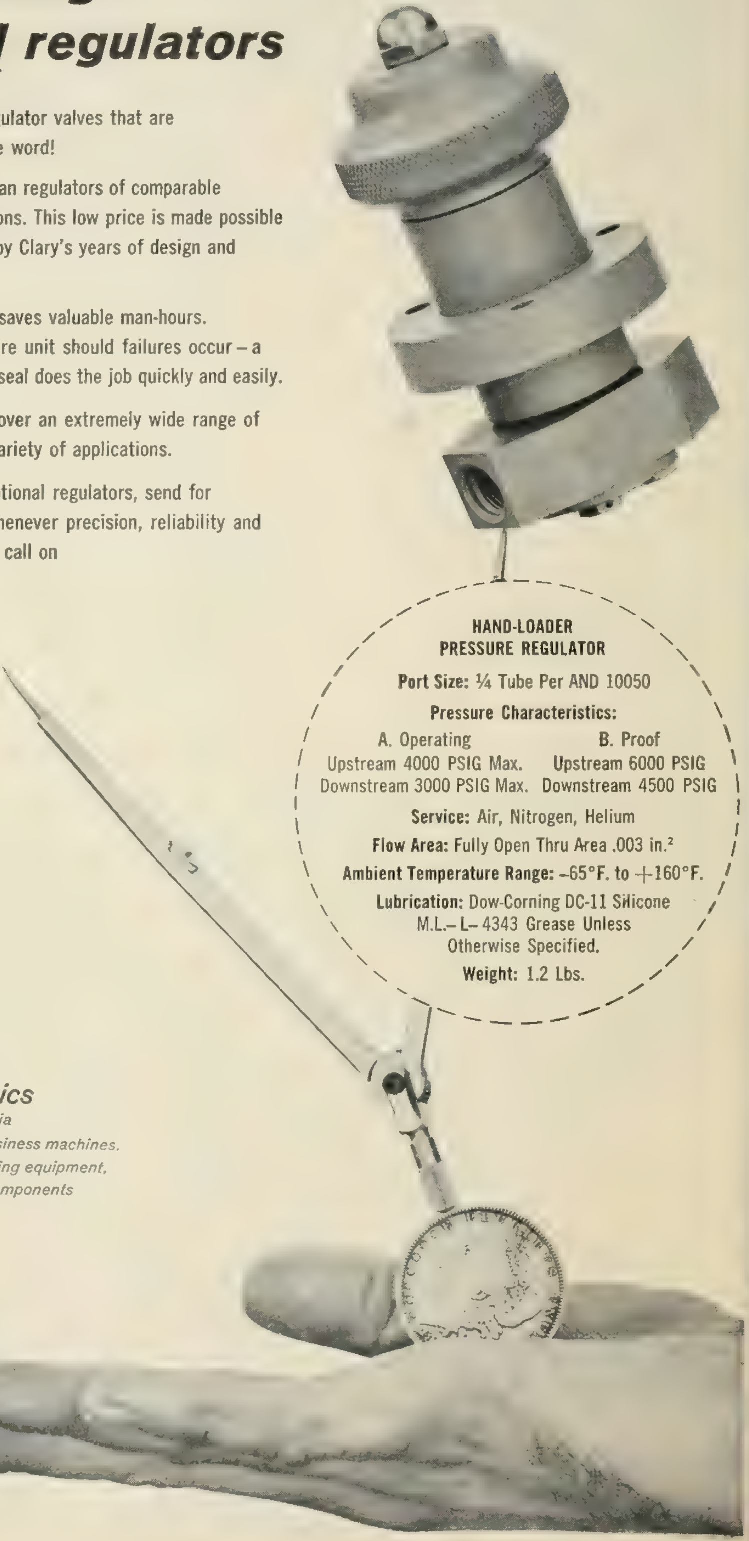
Here at last...hand-loader type regulator valves that are economical in the true sense of the word!

First, they are far less expensive than regulators of comparable quality and performance specifications. This low price is made possible by a unique, simplified design and by Clary's years of design and manufacturing experience.

Second, their ease of maintenance saves valuable man-hours. There's no need to remove the entire unit should failures occur – a simple replacement of the "0" ring seal does the job quickly and easily.

Third, because they are adjustable over an extremely wide range of pressures, you can use them in a variety of applications.

To find out more about these exceptional regulators, send for technical bulletin #CD-150. And whenever precision, reliability and versatility are factors in your plans, call on Clary for complete services.



HAND-LOADER PRESSURE REGULATOR

Port Size: ¼ Tube Per AND 10050

Pressure Characteristics:

A. Operating	B. Proof
Upstream 4000 PSIG Max.	Upstream 6000 PSIG
Downstream 3000 PSIG Max.	Downstream 4500 PSIG

Service: Air, Nitrogen, Helium

Flow Area: Fully Open Thru Area .003 in.^{2}

Ambient Temperature Range: –65°F. to +160°F.

Lubrication: Dow-Corning DC-11 Silicone M.L.– L– 4343 Grease Unless Otherwise Specified.

Weight: 1.2 Lbs.

Clary is one of the nation's largest manufacturers of rocket and missile valves. Other devices include: ABSOLUTE PRESSURE REGULATOR that maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and –65°F. to +350°F.; and DIFFERENTIAL PRESSURE REGULATOR that maintains an outlet pressure of 6 PSIG ±.25 with flow variations from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and –65°F. to +350°F.

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Clary Dynamics
San Gabriel, California
Manufacturers of business machines. electronic data-handling equipment, aircraft and missile components

First public disclosure . . .

Report Pinpoints Red Launch Base

Czech article says new satellite and missile base is located above the Aral Sea—new details on Mechta are also revealed.

By Paul Means

WASHINGTON—The Soviet Union's new missile and satellite launching base—in operation less than a year—is northeast of the Aral Sea in the Republic of Kazakh, approximately 70 miles north and east of the city of Aral'sk.

The coordinates (47 N, 62.5 E) of the new Russian "Cape Canaveral" were publicly revealed for the first time in the June 9th edition of a Czechoslovakian aviation journal. The journal, *Kridla Vlasti,* also disclosed new specific information about the Soviet sun orbiter *Mechta.*

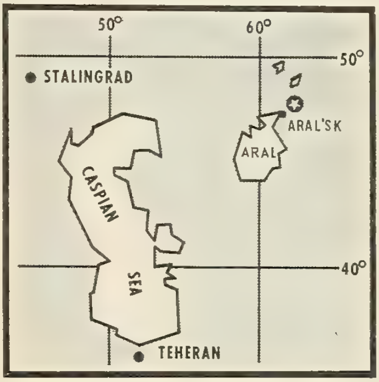
The Czech article was translated by the Central Intelligence Agency for publication in the Department of Commerce's Office of Technical Services bulletin last week.

According to reliable sources, the Czech article was accurate in its listing of the base's coordinates, which place it one degree east and one minute north of Aral'sk, but was inaccurate in its description of the location. The article reported the location to be in "an area northeast of the Ural lakes, on the dividing line between Europe and Asia"—about 700 miles away from the coordinate location.

The IRBM, ICBM, and space vehicle launching base has been in operation less than a year, according to M/R sources. *Mechta* was one of the first vehicles to be launched from the new base.

The old Soviet base was at Kapustin Yar at the bend in the Volga River near Stalingrad. (See M/R, Feb., 1958, p. 61). M/R in the 1958 article revealed that the Kapustin Yar base was within tracking distance of the Air Force radar stations at Samsun, Turkey, in the Elburz mountains north of Tehran, and at a third position north of Meshéd.

The Czech article said *Mechta's* first stage developed 600,000 lbs. of thrust. The main engine produced 440,000 lbs. of thrust, and two auxiliary solid motors—which were not ignited until the vehicle had reached an altitude of about 2000 meters—developed a thrust of about 80.000 lbs. each.



RED BASE'S location, according to the coordinates given in the Czech article, is northeast of the Aral Sea, about 70 miles from Aral'sk.

• **Two stages?**—Experts on Russian missiles speculate that the main engine of the *Sputnik* and *Mechta* vehicles may be a two-engine combination such as *Atlas,* with each engine developing 220,000 lbs. of thrust. This is substantiated by the Czech article's report that the booster was clamped down until full thrust was achieved.

The liquid propellant for all three stages, according to the article, was a hydrocarbon fuel with a boron additive, and liquid oxygen. The ratio of fuel to oxydizer, the same for all three stages, was 2.4:1.

The second stage, a modified IRBM, did not separate from the booster until 2.5 seconds after ignition, giving it time to achieve full thrust. The third stage separated in a similar manner.

The exhaust nozzles and combustion chambers were lined with tungsten. The rocket motors had a mixing chamber in front of the actual combustion chamber, making it possible for the combustion chamber to attain a pressure of 23.6 kg/cm^2 which, by expanding the exhaust orifice, dropped to 0.7 kg/cm^2.

• **Chamber cooled**—Though burning temperature was approximately 3200°C, the temperature of the combustion chamber walls and exhaust nozzles was kept below 600°C by using the rocket fuel as a coolant circulating through special channels around the combustion chambers.

Thermocouples regulated the flow of the coolant fuel, which when warmed was returned to the fuel tanks and re-mixed with the cold fuel.

The injection pressure of the fuel varied from 135 to 180 kg/cm^2, according to the thrust required to maintain a speed predetermined by an integrator working in conjunction with the stabilizing gear of the third starge.

The injectors for fuel and oxygen in the third-stage rocket motor were equipped with magnetic needle valves controlled by perforated program cards.

The fuel pumps, used in all three stages, were driven by steam turbines which in turn were driven by diverting burning gases from the combustion chamber. A special compressor was used at launch.

The article stated that all pre-launch functions were automatic.

The trajectory, according to the article, had been previously fed into perforated aluminum cards, which, with the aid of two electronic computers, directed the vehicle's third-stage guidance system. The ground station was located one kilometer from the firing base.

The flight path of *Mechta* was monitored, according to the article, by 13 ground stations in Russia (one main station and 12 secondary stations), equipped with Doppler, radar, and photo-theodolite instruments. All three equipment systems were set up on a common mounts which could rotate horizontally as well as vertically. The stations were interconnected by cable.

Exploring Beryllium's Potential

But Martin Co. metals researcher says beryllium technology must be greatly expanded before it can become a truly useful material. Progress is defined in overcoming extreme brittleness and in working the metal.

by Charles J. Giemza

BALTIMORE—Beryllium's unusual combination of mechanical and physical properties is generating interest in its potential application to missile and other airframe structures. Investigation so far, however, indicates the lightweight metal's utilization in structures will depend upon qualities beyond sheer mechanical superiority.

For before these advantages can be realized, it will be necessary to substantially enlarge beryllium technology.

The necessary transition from the basic material forms to an element of the structure must be accomplished without incurring a significant compromise of the material's virgin characteristics, presuming the original properties approach ideality.

Admittedly, it is possible to employ beryllium—as it is presently known—in structures where the design conditions are quite conservative. But this approach is hardly ingenious and produces no contribution. Indeed, it is an imposed limitation which may forestall a more rapid and complete development of structural beryllium.

Furthermore, the seriousness of possible catastrophic structural failures, if underdeveloped beryllium should be employed, cannot be minimized. The assurance of beryllium's structural integrity will be achieved only when the damaging factors are clearly established and—having been identified—are either reduced or eliminated through defined fabrication processes and design.

- **Re-entry vehicle design**—Efficient structural design implies that the structural material would be fully exploited. The comparison of beryllium's individual properties—density, strength, stiffness—to other materials' properties may be misleading. Even the combination of beryllium's properties may not be particularly advantageous in some design applications. Therefore, structural indices of strength-density or modulus-density ratios, while indicating an apparent advantage, provide no clue to beryllium's superiority.

About the Author:

Mr. Giemza is supervisor of metals research at The Martin Co., Baltimore. For his part in developing the nation's first beryllium structure meeting primary structural standards, Giemza received the Achievement of the Year Award from the American Rocket Society.

In one hypothetical design of a reentry vehicle, advantage was taken of all mechanical and physical properties—strength, stiffness, density, specific heat, themal conductivity, oxidation resistance and creep resistance. The design—a composite, thermally protected beryllium structure—was superior (for the mission profile in question) to alternative designs made from other materials in these respects:

- Auxiliary cooling was not required.
- The beryllium composite structure was substantially lighter.
- Attainment of an arbitrary temperature (above the initial condition) occurred appreciably after that developed in the alternative designs—thus effectively extending the range and preserving a higher structural strength throughout the mission.
- A critical dynamic condition was eliminated.

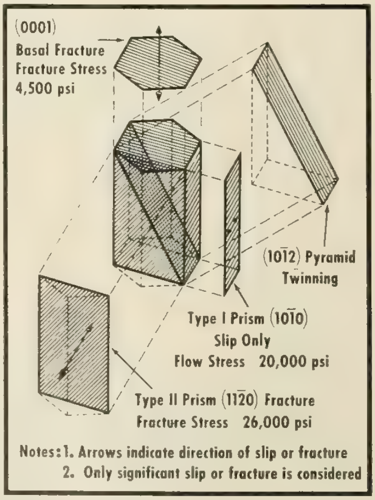

(0001)
Basal Fracture
Fracture Stress
4,500 psi
$(10\bar{1}2)$ Pyramid
Twinning
Type I Prism $(10\bar{1}0)$
Slip Only
Flow Stress 20,000 psi
Type II Prism $(11\bar{2}0)$ Fracture
Fracture Stress 26,000 psi
Notes: 1. Arrows indicate direction of slip or fracture
2. Only significant slip or fracture is considered

FIG. 1—**Beryllium unit cell, principal slip and fracture planes.**

Speculative design studies do not, however, solve the immediate problems which prevent the realization of these designs. Excepting the semi-structural and non-structural employment of beryllium, no practical design experience has been generated. Moreover, no commercial beryllium product has been developed which could be construed as a primary airframe structural material. Although these observations appear pessimistic, one must consider that the premature employment of beryllium would not provide a fair evaluation of its total potential.

If the time when structural beryllium becomes available is to be shortened, the comparatively modest beryllium development effort will require new emphasis. It would be timely, therefore, to review the factors which would have a bearing on the attainment of goals in the development of structural beryllium.

- **Crystallographic texture**—Because the developed properties and characteristics of beryllium depend on the arrangement of crystals in the polycrystalline aggregate, it is necessary to explicitly define the fabrication parameters and consequently the mode of fabrication which will impart the desired texture.
- **Forming**—Forming which is performed subsequent to the original fabrication—will alter what may have been an ideal texture. In addition, the rather poor formability of beryllium will require a thorough study in this respect. The possible alteration of the crystallographic texture by forming will require a specification of the de-

(continued on page 29)

Sixth sense for the hunter-killers

> **"Our greatest need is for longer range detection equipment and the weapons to give us the kill capability by the time we have the extended range search and identification gear."—Rear Admiral John Thach, Commander Anti-Submarine Defense Group ALFA.**

The Navy's Special Task Group Alfa—the Hunter-Killers who defend against enemy submarines—must find faster and deadlier means of detecting and destroying enemy submarines in time of war. Submarines launching nuclear warheads could destroy major cities and military installations in a matter of minutes.

ARMA has accepted the challenge to provide for the Navy's greatest ASW need, insuring our future by swifter and surer elimination of the undersea threat.

This and other top-priority projects are underway at ARMA—longtime developer of new concepts and equipment for the American military.

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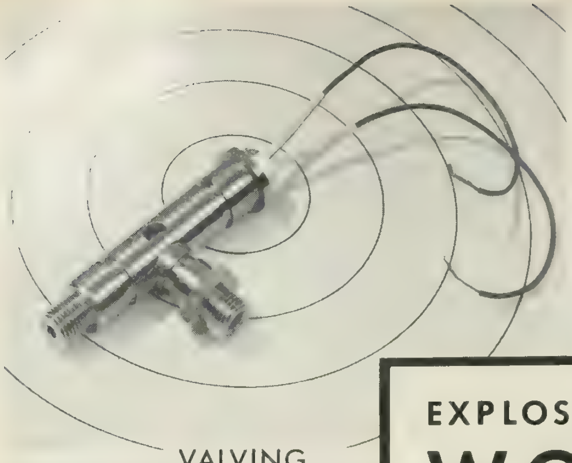
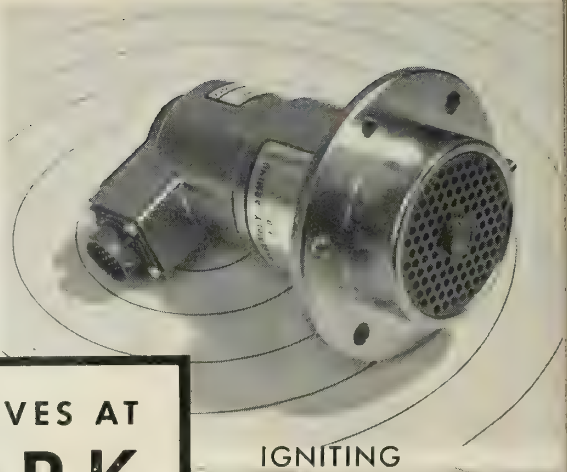
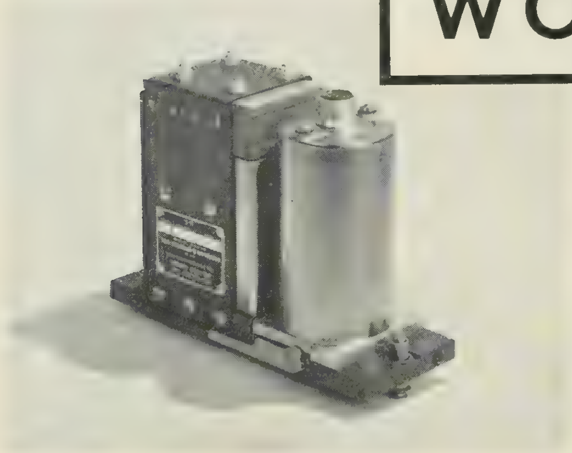
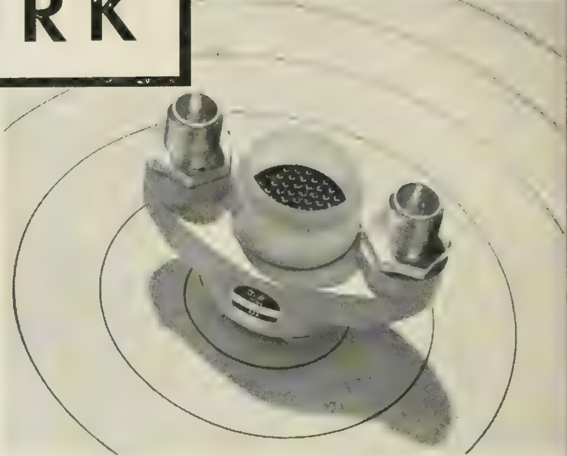
EXPLOSIVES AT WORK


VALVING


IGNITING


DESTRUCTING


DISCONNECTING

missile hardware

When it comes to the problems of putting propellants and explosives to work on the actuating jobs in and around missiles, Beckman & Whitley offers a background gained in ten years of pioneering. Examples shown are just a few selections of solutions to typical problems.

They include a zero-leakage re-usable non-contaminating valve, a lanyard-armed destruct package, a rocket-engine starter for operation at altitude, and a standard electrical connector adapted for propellant-actuated disconnecting. Our case-history files are full of other examples, and if these don't happen to touch on your present problems, some of the others undoubtedly will.

This engineering capability, these production facilities, and our tradition of performance and reliability are at your disposal. Applications-engineering assistance is available in the solution of your problems.

Beckman & Whitley INC.

SAN CARLOS 16, CALIFORNIA

Circle No. 8 on Subscriber Service Card.

Missiles & Rockets Astrolog / September 1959

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
SPACE VEHICLES			
ATLAS-ABLE (NASA)	STL, prime; GE/Burroughs, Arma, guidance; Rocketdyne, Aerojet-General, ABL, propulsion	Orbit 200-lb. vehicle around moon or send into deep space	Moon orbit attempt scheduled for October
CENTAUR (NASA)	Convair, prime; Pratt & Whitney/JPL, propulsion	Soft-land 730-lb. on moon	First test flight in fall, 1961
COURIER (ARPA-Army)	Army Signal Corps, prime	Delayed repeater communications satellite	R&D; satellite in advanced stage
DISCOVERER (ARPA-AF)	Lockheed, prime	Thor-Agena launchings of early stabilized satellites	6 launched; 3 in orbit and stabilized; ejected capsules not recovered
DYNA-SOAR I (Air Force)	Boeing and Martin/Bell, competing	Boost-glide orbital test vehicle	Late study stage
JUPITER-C (NASA)	ABMA/Chrysler, prime; Sperry, guidance; Rocketdyne, JPL, propulsion	Early satellite booster; small payload	Being phased out
JUNO II (NASA)	ABMA/Chrysler, prime; Ford Instrument, guid.; Rocketdyne/JPL, prop.	Early deep space booster; small payload	Being phased out
MERCURY (NASA)	NASA, prime; McDonnell, capsule	First manned satellite	Capsule testing being conducted
MIDAS (ARPA-Air Force)	Lockheed, prime	Early-warning satellite; detect ICBM launchings by infrared before birds leave pad	R&D
MRS. V (ARPA)	No prime announced	Manueverable, recoverable space vehicle; also known as DYNA-SOAR II	Early R&D
NOTUS (ARPA-Army)	G.E., polar communication system	Overall instantaneous repeater communications satellite program	R&D
NOVA (NASA)	Rocketdyne, prime; Rocketdyne, propulsion	Clustered 6 million lb. booster	Early R&D on 1.5 million lb. engines
ORION (ARPA-Air Force)	General Atomic	Space station launched by series of atomic explosions	Feasibility studies under way; tests may be attempted
SAMOS (ARPA-Air Force)	Lockheed, prime	Reconnaissance satellite; formerly Sentry	R&D; stabilization already achieved in DISCOVERER series
SATURN (ARPA-Army)	Army Ordinance Missile Command, prime; Convair/Pratt Whitney, propulsion	Clustered 1.5 million lb. thrust booster; liquid TITAN second stage; CENTAUR third stage	Static test early 1960; first booster flight one year later; operational about 2 years
SCOUT (NASA)	Chance Vought, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Allegany/Thiokol, propulsion	Four-stage satellite launcher; 200-300 lb. payload in orbit	Operational next spring
SUZANO (ARPA)		Space platform to be used as base for staging and other missions	Feasibility studies
THOR-ABLE (NASA)	STL, prime; Rocketdyne/Aerojet-General/ABL, propulsion	Early deep space booster	Sun orbit shot in December
THOR-DELTA (NASA)	STL, prime; IT&T, guidance; Rocketdyne/Aerojet-General/Allegany,prop.	Put 65-lb. satellite in orbit around moon	R&D; first flight early 1960
TRANSIT (ARPA-Navy)	Lockheed and Johns Hopkins Laboratory, prime	Navigational satellite	R&D
TRIBE (ARPA)		Family of space launching vehicles	Planning
VANGUARD (NASA)	Martin, prime; Minneapolis-Honeywell, guidance; GE, Aerojet, ABL, Grand Central, Atlantic Research, Thiokol, propulsion	First planned satellite booster; small payloads	Being phased out; one bird left
VEGA (NASA)	JPL/Convair, prime; GE, guidance; Rocketdyne/JPL/GE, propulsion	Advanced space vehicle with ATLAS; second stage start-restart; can put 980 lbs. around moon	First flight in fall, 1960
X-15 (NASA-Air Force)	North American prime; Thiokol, prop.	Rocket plane; 3600 mph;	Powered flight expected this fall
MISSILES & ROCKETS			
ABLE (Navy)	Avco, prime	ASW surface-to-underwater; 500 lb. solid; conventional	Deployed on destroyer escorts

ASROC (Navy)	Minneapolis-Honeywell, prime	Surface-to-underwater; solid rocket torpedo; nuclear	R&D
ASTOR (Navy)	Westinghouse, prime	ASW underwater to underwater; rocket torpedo; nuclear	R&D
ATLAS (Air Force)	Convair, prime; GE/Burroughs, ARMA, guidance; Rocketdyne, propulsion	ICBM; more than 5500-mile range; liquid; nuclear	29 launchings of test vehicles all types: 14 successes, 7 partial; 8 failures; expected operational this month
ALBM (Air Force)	Douglas, prime	Air launched ballistic missile; more than 1000-mile range; solid; nuclear	Design study
ARM	No contract announced	Anti-radar missile	R&D
BOMARC (Air Force)	Boeing, prime; Westinghouse; guidance; Marquardt, A model/Thiokol B, propulsion	Air-breathing surface-to-air interceptor; A model liquid, B solid; 200-400 m. range, Mach 2.7, nuclear	A model operational; B under R&D
BULLPUP (Navy)	Martin, prime; Republic, guidance; Thiokol, propulsion	Air-to-surface; 4-mile range; conventional 250-lb. bomb	Deployed with Atlantic and Pacific Fleets; bigger model under R&D
CORPORAL (Army)	Firestone, prime; Gilfillan, guidance; Ryan, propulsion	Surface-to-surface; 75-mile range; liquid; nuclear	Deployed with U.S. & NATO troops in Europe
CORVUS (Navy)	Temco, prime; Texas Instrument, guidance; Reaction Motors, propulsion	Air-to-surface; pre-packaged liquid; radar homing; about 100-miles range	First successful test July 18, 1959
CLAYMORE (Army)	No contract announced	Anti-personnel missile	R&D
CROSSBOW (Air Force)	Radioplane, prime; Bendix, guidance; Westinghouse, propulsion	Air-to-surface; turbojet; radar homing; 200-mile range	R&D
DAVY CROCKETT (Army)	In-House Project at Rock Island, Ill., arsenal	Surface-to-surface; solid; bazooka launched; sub-kiloton nuclear warhead	R&D
EAGLE (Navy)	Bendix, prime; Sanders, guidance	Air-to-air; 100-mile range; nuclear; for launching from relatively-slow aircraft	Early R&D
FALCON (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion	Air-to-air; 5-mile range; Mach 2; solid; conventional	GAR-1D & GAR-2A & GAR-3 operational; GAR-4 & GAR-9 under R&D
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air; unguided; 1.5-mile range; nuclear	Operational
GIMLET (Navy)	No contract announced	Air-to-surface; unguided; considered highly accurate	R&D
HAWK (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 20-mile range; solid; conventional; designed to hit low-flying planes	Operational; units training for early deployment
HONEST JOHN (Army)	Douglas, prime; Hercules, propulsion	Surface-to-surface; unguided; 16.5-miles range; nuclear	Operational; deployed in Europe
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Airbreathing air-to-surface; 500-mile range; Mach 1.7; turbojet; nuclear	Nearly operational; to be launched from B-52G intercontinental bombers
JUPITER (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	IRBM; liquid; nuclear	Being deployed with Italian troops in Italy; 20 launchings: 14 successes; 5 partials; 1 failure
LACROSSE (Army)	Martin, prime; Federal Telecommunications Laboratories, guidance; Thiokol, propulsion	Surface-to-surface; highly mobile; 20-mile range; solid; nuclear	Operational; units being trained
LITTLE JOHN (Army)	Emerson Electric, prime; ABL, propulsion	Surface-to-surface; unguided; 10-mile range; solid; nuclear	Nearly operational; units training with it
LOBBER (Army)	No contract announced	Surface-to-surface; cargo carrier; 10-15 mile range; also can drop napalm	Studies
LULU (Navy)	No contract announced	Surface-to-surface; nuclear	R&D
MACE (Air Force)	Martin, prime; AC Spark Plug, guidance; Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet & solid; nuclear	Being deployed with U.S. troops in West Germany
MATADOR (Air Force)	Martin, prime; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 650-mile range	Being turned over to West Germans; also deployed in Far East
MAULER (Army)	No contract announced	Surface-to-air; IR guidance; field weapon	R&D
MINUTEMAN (Air Force)	Boeing, prime; Autonetics, guidance; Thiokol, propulsion	2nd generation ICBM; solid; mobile; nuclear	R&D. Expected to be operational by late 1962 or early 1963

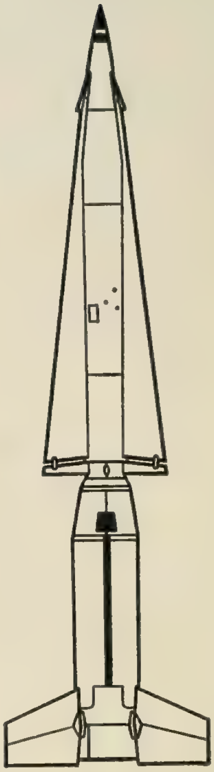
MISSILE A (Army)	No contract announced	Surface-to-surface; 65-70 mile range; solid	Design studies
NIKE-AJAX (Army)	Western Electric, prime; Western Electric, guidance; Hercules Powder, propulsion	Surface-to-air; 25-mile range; Mach 2.5; solid & liquid; conventional	Deployed in U.S., Europe & Far East
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules & Thiokol, propulsion	Surface-to-air; 80-mile range; Mach 3+; nuclear	Rapidly replacing NIKE-AJAX
NIKE-ZEUS (Army)	Western Electric, prime; Bell Telephone, guidance; Grand Central, propulsion	Anti-missile; 3-stage; 200-mile range; solid; nuclear	R&D; major components being tested; first tests against ICBM's to be in PMR; first launched Zeus fell apart in flight Aug. 26
PERSHING (Army)	Martin, prime; Bendix, guidance; Thiokol, propulsion	Surface-to-surface; solid; 700-mile range; nuclear	R&D; to replace REDSTONE
POLARIS (Navy)	Lockheed, prime; GE, guidance; Aerojet-General, propulsion	Underwater and surface-to-surface; solid; 1500-mile range; nuclear	37 launchings of test vehicle; 26 successes; 9 partial; 2 failures; launched from surface ship Aug. 27, 1959; expected operational late 1960
RAVEN (Navy)	No contract announced	Air-to-surface; about 500-mile range	Study
REDEYE (Army)	Convair, prime	Surface-to-air; 20-lb. bazooka-type; IR guidance; solid; conventional	R&D
REDSTONE (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; nuclear	Deployed with U.S. troops in Europe
REGULUS (Navy)	Chance Vought, prime; Sperry, guidance; Aerojet-General, propulsion	Surface-to-surface; turbojet & solid; 500-mile range; nuclear	Deployed aboard U.S. submarines
SERGEANT (Army)	JPL/Sperry, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; more than 75-mile range; nuclear	Production. To replace CORPORAL
SHILLELAGH (Army)	Aeronutronics, prime	Surface-to-surface; lightweight; can be vehicle-mounted	R&D; expected to be operational mid-1960's
SIDEWINDER (Navy)	Philco, prime; Avion, guidance; Naval Powder Plant, propulsion	Air-to-air; IR guidance; 6-7-mile range; conventional	Deployment with Naval and Air Force units
SLAM (Air Force)	No contract announced	Surface-to-surface; low-altitude; supersonic; nuclear-powered ramjet; nuclear	Study-R&D
SNARK (Air Force)	Norair, prime; Northrop, guidance; Aerojet-General, propulsion	Surface-to-surface; 5500-mile range; solid and turbojet; Mach .9; nuclear	Deployed at Presque Isle, Maine
SPARROW III (Navy)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Air-to-air; 5-8-mile range; Mach 2.5-3; solid; conventional	Operational with carrier aircraft; earlier SPARROW I obsolete
SUBROC (Navy)	Goodyear, prime; Kearfott, guidance; Thiokol, propulsion	Underwater or surface-to-underwater; 25-50 mile range; solid; nuclear	R&D
SS-10 (Army)	Nord Aviation, prime	Surface-to-surface; primarily anti-tank; 1600-yards range; 33 lbs. solid; wire guided; conventional	Operational with U.S. and French units; battle-tested in North Africa
SS-11 (Army)	Nord Aviation, prime	Surface-to-surface; also helicopter-to-surface; 3800-yard range; 63 lbs.; wire guided; conventional	Operational. Under evaluation by Army.
TALOS (Navy)	Bendix, prime; Farnsworth/Sperry, guidance; Bendix/McDonnell, propulsion	Surface-to-surface; 65-mile range; solid & ramjet; Mach 2.5; nuclear	Operational this year aboard cruiser Galveston
TARTAR (Navy)	Convair, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 10-mile range; Mach 2; 15 feet long & 1 foot in diameter; solid dual-thrust motor; conventional	Many test firings in Pacific; expected deployment 1960 as primary armament of guided missile destroyers; production
TERRIER (Navy)	Convair, prime; Reeves/FTL, Sperry, guidance; ABL, propulsion	Surface-to-air; 10-mile range; Mach 2.5; 27 feet long; solid; conventional	Operational with fleet
THOR (Air Force)	Douglas, prime; AC Spark Plug, guidance; Rocketdyne, propulsion	Surface-to-surface IRBM; 1500-mile range; liquid; nuclear	Operational; bases being set up in England, possibly Turkey soon; 42 launchings: 26 successes; 9 partial; 7 failures
TITAN (Air Force)	Martin, prime; Bell, Remington Rand, guidance; Aerojet-General, propulsion	Surface-to-surface ICBM; 5500-mile range; liquid; 90 feet long; nuclear	5 launchings test vehicles: 4 successes; 1 failure; expected to be operational late 1960-early 1961
WAGTAIL (Air Force)	Minneapolis-Honeywell, prime	Air-to-ground; low-level; solid; designed to climb over hills and trees	R&D
ZUNI (Navy)	Naval Ordnance Test Station, prime	Air-to-air, air-to-surface; solid; unguided rocket; 5-mile range; conventional	Operational

The man:

A U.S. Army missileman working with Nike Hercules missile equipment. The modern Army relies heavily on the special skills and knowledge of men like this who are trained extensively in military schools, and supported technically in the field by Army Ordnance Corps, Western Electric and Douglas field service men.

The mission:

Defense of U.S. cities. Army Nike Hercules units are already on duty at many key points...have the important assignment of guarding against enemy aircraft.



The missile:

Douglas-built Nike Hercules, product of a Douglas-Western Electric-Army Ordnance team, has successfully engaged supersonic drone targets at altitudes well over 60,000 feet. Other drone targets have been destroyed up to 100,000 feet, and at ranges beyond 75 miles.

Status	**Combat ready**
Range	**75 miles plus**
Speed	**Supersonic**
Warhead	**Nuclear or conventional**
Service	**U. S. Army**

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(continued from page 22)

gree of compromise or, alternatively, an initial fabrication history which would account for the effect of forming.

- **Joining**—Perhaps the most important requirement for transforming beryllium products into useful structural elements is the capability of being joined with no appreciable sacrifice in properties. The methods of joining which are available are: mechanical fastening, brazing, welding, and adhesive bending. Each method has certain advantages but all have disadvantages which will require solution.

Mechanical fastening will require a study of twinning damage, stress concentrations, joint configurations, drilling techniques and remedial treatments before and after assembly. Brazing will require study of intermetallic compounds, brazing alloys, protective atmospheres, joint configurations, brazing parameters, and crystallographic effects. Welding will pose similar but more severe problems than brazing. Adhesives will have a limited application and present no significant problems.

- **Design Information**—The anisotropic character of wrought beryllium and the damaging effect of many factors will require new criteria for characterizing beryllium's design properties.

- **Alloying**—Although alloying in itself may not prove feasible, it would provide a basis for defining the influence of impurity phases in heat affected regions and for developing filler metals for welding and brazing.

- **Crystal Structure**—Perhaps the most important single physical factor that has impeded the development of structural beryllium which would be superior to conventional metals for a given application has been the anisotropic character of the crystal structure. The atomic arrangement—a hexagonal close-packed system—is deficient in its ability to flow plastically for arbitrary stress states. Essentially, three atomic planes govern the brittle or ductile behavior of beryllium.

These planes, the direction in which flow or fracture occur, and the stress required to initiate flow or fracture are illustrated for a unit cell in Fig. 1. The $10\bar{1}0$ prism plane has been established as the principal slip system and, as measured in single crystal studies, requires about 20,000 psi to initiate slip. The 0001 basal plane and $11\bar{2}0$ prism plane are the principal sources for fracture—having fracture stresses of about 4500 psi and 26,000 psi, respectively, as measured for a single crystal.

Comparing the three stress levels, it is apparent that the low ductility of beryllium is dependent on the resolved stress to which the basal planes are subjected.

As the number of crystals increases, the stress state required for plastic flow or fracture will change—depending on the geometric relation of the crystals—because of the interaction among the crystals. However, plastic flow or brittle fracture of the polycrystalline aggregate would be governed by the three atomic planes at stress levels somewhat proportional to those for single crystals. If the resolved stress normal to the (0001) basal plane is maintained below a critical value for a given applied stress, then the plastic flow of the $(10\bar{1}0)$ prism planes will predominate.

The natural conclusion can then be drawn that it would be desirable to align the basal planes of all the crystals in the polycrystalline aggregate parallel to the applied force; then the stress normal to the basal planes would be zero. Practically, it would be impossible to obtain this ideal arrangement, but fortunately when a large number of basal planes are more or less parallel, then ductility is evidenced. In fact, sheet has been produced which has developed elongations in excess of 50% in the plane of the sheet.

- **Fabrication Process**—In the past, the study of beryllium crystal structures and related mechanical properties indicated the following: the mechanical characteristics of wrought beryllium are attributable, when all other influencing factors are held constant, to the crystallographic texture. More specifically, the mechanical properties, the characteristic response to a stress state, and the developed anisotropy of beryllium depend on the manner and degree of deformation. Such factors as grain size and impurities still required solution.

The employment of castings as a starting condition for wrought forms did not meet with success. Fortunately, a fine-grained structure was made possible by the introduction of semi-powder metallurgy techniques. The powder—produced by attritioning beryllium chips—develops an oxide coating which inhibits grain growth during processing. The influence of the second factor, impurities, was minimized by employing inert atmospheres and vacuum.

Having identified and partially resolved the important embrittling problems, it was possible to produce various shapes by hot-pressing (sintering under pressure); hot-pressing and extruding, and hot-pressing, extruding, and rolling. In general, while the processed metal was mechanically superior to shapes produced from castings, the material did not develop the qualities necessary for efficient structural design.

Paradoxically, isotropic material, produced by hot-pressing, and the highly anisotropic material, produced by hot-pressing and extruding, exhibited undesirable mechanical characteristics. The former developed only moderate strength $F_{tu} = 40 - 50{,}000$ psi; $F_{ty} = 20 = 30{,}000$ psi and low ductility (0 - 1%). On the other hand, extrusions, made with large reductions, developed highly directional properties. In the direction of extrusion, high strength ($F_{tu} = 100{,}000$ psi) and high ductility (10%) were developed. However, because of the highly aligned atomic planes, the transverse properties were very poor. Furthermore, the extrusions would not withstand, without fracture, even moderate eccentric loading.

When the semi-powder metallurgy techniques were extended to the fabrication of sheet (hot-pressing, extruding and cross-rolling), it was demonstrated that, in addition to the development of

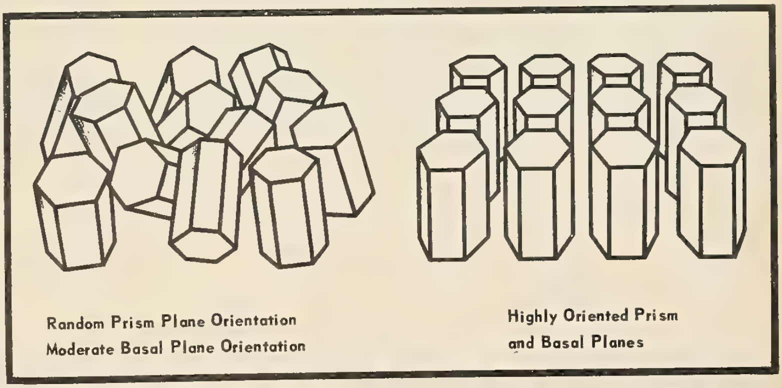
Random Prism Plane Orientation
Moderate Basal Plane Orientation
Highly Oriented Prism
and Basal Planes

FIG. 2—Crystallographic texture in moderately and highly worked beryllium powder.

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many joining problems . . .

rather high strength, a phenomenal increase (in excess of 50%) in the ductility was obtained. Although the mechanical properties were exhibited in tests on small specimens, the results of these investigations established the practical significance of preferred crystal orientation. The preferred crystal orientation, termed "layer texturing," is identified, in the case of sheet material, with a predominant number of crystals having their basal planes parallel to the plane of the sheet. One deficiency arises, however, in that the anisotropy of the single crystal is manifested, i.e., the thickness direction of extruded cross-rolled sheet did not exhibit measurable plastic flow. Furthermore, beryllium sheet produced by this technique was sensitive to size embrittlement. The size embrittlement is simply a loss of ductility as the size of the element increases—which is in some manner related to the restraint developed in larger elements—thereby generating a resolved fracture stress sufficiently large to govern failure.

- **Hot-Upsetting**—Recently, a novel method based on semi-powder metallurgy techniques was developed for producing beryllium sheet which would better satisfy the structural requirements of airframes. The method, called "hot-upsetting," although elementary in character, resolved many of the problems of brittleness and may have a far-reaching influence in prescribing the manner in which beryllium is fabricated. The sheet produced by hot-upsetting develops a strength in excess of 70,000 psi (governed by the amount of hot work) and an elongation in excess of 10%.

In a comprehensive evaluation of the mechanical characteristics of wrought beryllium, sheets made by three methods—hot-pressing, hot-upsetting, and extruding and cross-rolling—were comparatively tested. Respectively, the processes imparted increasing amounts of texturing—the hot-pressed sheet represented an essentially isotropic condition; the extruded and cross-rolled represented the highly anisotropic condition; and the hot-upset sheet represented an intermediate state of preferred orientation.

Tensile tests showed that elongation in the plane of the sheets was essentially proportional to the degree of hot work. The hot-upset sheet exhibited a ductility intermediate to sheet produced by the other two methods (hot-pressed, 0-1%; hot-upset 10-12½; extruded and cross-rolled, over 25%). In plane stress tests, in which $\sigma_x = \sigma_y$-$\sigma_z = 0$, the inverse held true, i.e., the highly worked sheet exhibited the greatest embrittlement. In another evaluation, a measure of the bend ductility as a function of size or size embrittlement was made. Although the essentially isotropic hot-pressed sheet exhibited a uniaxial ductility of about 1%, its bend ductility was considerably superior to the extruded and cross-rolled sheet. However, the trend for size embrittlement increased with increasing sheet size and it was significantly inferior to hot-upset sheet.

The importance of bend ductility cannot be quantitatively established, at this time, for structural applications, but it is a well-known precept that ductility, while not accounted for in stress analysis, is an essential quality necessary for redistributing high local stresses and for withstanding the embrittling effect of complex stresses.

A characterization of the disposition of crystals is shown in Fig. 2 for sheet made by two techniques. On the left, a moderately oriented crystal structure represents sheet produced by moderate deformations such as hot-upsetting. On the right, the highly aligned structure is developed as in extrusion and cross-rolling.

A log-log plot illustrating the bend ductility of beryllium sheet produced by three different fabrication methods is shown in Fig. 3. The permanent deflection in inches is plotted on the ordinate, and a width-to-thickness ratio is plotted on the abscissa. A constant width-to-thickness may not behave in the same way. In addition to the plot of data, some typical bend ductility specimens are shown in Fig. 4 for extruded and cross-rolled and hot-upset sheet. The highly developed crack pattern of the ductile extruded and cross-rolled sheet is coincident with the alignment of the $11\bar{2}0$ prism planes.

The conclusion that can be drawn from the foregoing discussion of the three sheet fabrication processes can be summarized as follows:

1) An isotropic polycrystalline aggregate cannot develop satisfactory mechanical properties because of the lack of hot work.

2) A large amount of the hot work or reduction can be associated with a highly preferential grain structure and

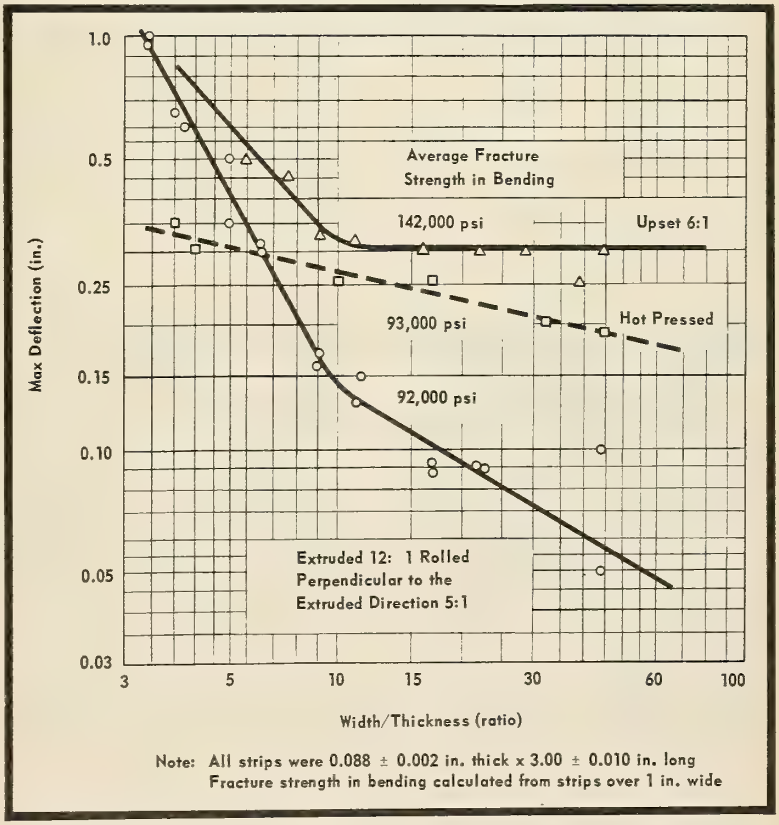


FIG. 3—Bend ductility of beryllium as it is influenced by size and the method of fabrication. A constant width-to-thickness may not behave in the same way.

therefore anisotropic properties. Although the mechanical properties developed by large reductions are apparently high in certain directions (as determined in a tensile test) under practical circumstances, even ductile beryllium becomes brittle.

3) The manner and degree of hot work which produce a prescribed texture are necessary antecedents to the development of a structural beryllium.

The structural superiority of hot-upset sheet—established in the comparative examination of sheets produced by several fabrication techniques—has been demonstrated in the preliminary sense. Although definitive fabrication parameters have not yet been established, it is expected that the texture requirements for structural beryllium are significant and essential.

- **Brittleness**—The factors which cause the embrittlement of beryllium have been identified, and a relatively large improvement has been made toward eliminating this deficiency. Even though a quantitative design value for critical embrittlement cannot be established, the incipience of brittle failure appears to remain an important consideration. If the causes which bring about embrittlement of beryllium are fully understood, then it should be possible through process control and design to circumvent the critical conditions.

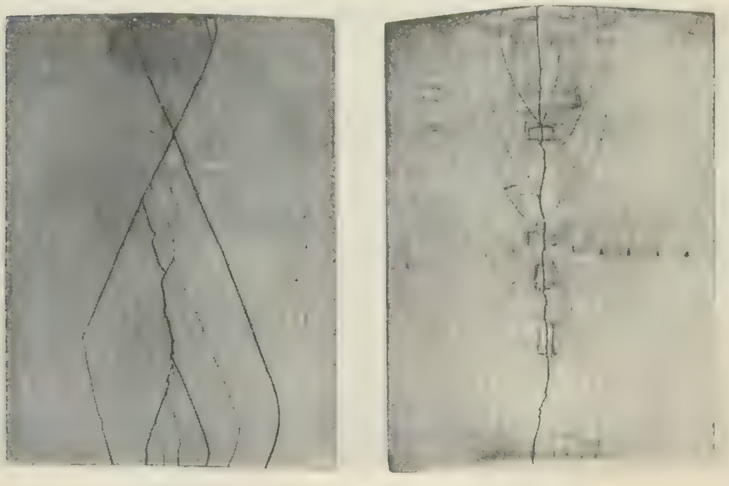
A complete specification of the causes of embrittlement would include the following:

1) Grain Size: Semi-powder metallurgy techniques have eliminated this factor as an initial cause for embrittlement. However, subsequent brazing, welding and processing or prolonged exposure at elevated temperature may bring about grain growth.

2) Transition Temperature: The impact transition from brittle to ductile behavior occurs above 400°F and increases readily with increased impurities, cold work, and stress state. The impact strength of beryllium is much below the poorest structural alloys. Although impact strength has been a consideration for material selection, the value of this property in design applications has not been quantitatively established. However, it appears that finite strain rates rather than impact would govern in the intended applications.

3) Impurities: Impurities in the form of oxides and trace metals can produce significant embrittlement. The trace metals occur in form of impurity phases—alloys or intermetallic compounds, and their influence can be manifested as a reduction of ductility at lower temperatures or grain boundary weakening at elevated temperatures (about 900°F, depending on the material) as the result of possible precipitation of the impurity phases. Although the initial purity can be assured, the residual trace impurity content may produce a measurable effect when it is combined with other factors.

4) Notches: It appears that notch sensitivity will remain an important cause of embrittlement in beryllium. However, it will be possible to minimize the sensitivity to notch embrittlement by rigidly observing a defined fabrication history.



Extruded
Cross-Rolled

Hot-Upset Sheet
6:1 Ratio

FIG. 4—Crack patterns in bend ductility test specimens of beryllium sheet fabricated by two techniques. Note highly developed crack patterns on the left.

5) Stress State: Because of the low fracture stress of the basal planes, biaxiality and triaxiality may produce resolved stressed sufficiently high to cause failure at low applied stresses. The magnitude of this effect can be greatly diminished by the development of a prescribed crystallographic structure. An associated cause of embrittlement, the size effect (not necessarily related to the statistical occurrence of major flaws), can at the same time be reduced when the specified fabrication history is observed.

6) Twinning: The phenomenon called twinning is an alteration of the crystal structure generated by machining or forming below the recrystallization temperature. This factor can severely embrittle the most ductile beryllium. Generally, annealing and/or etching will restore the ductility of the metal.

- **Structure property tests**—The superiority of beryllium to other structural metals must also be weighed with its deficient characteristics. Strength and ductility determined by standard test techniques have been adequate indices for characterizing the structural merit of conventional metals. However, the behavior of beryllium is markedly influenced by factors which are normally considered unimportant. These factors have been briefly discussed relative to embrittlement. Now it becomes necessary to establish a standard for qualifying the structural utility of beryllium as a function of these factors.

The standard tensile test is an unconservative measure of beryllium's mechanical characteristics. As the gage width (size of the element) increases, ductility decreases; and, while the embrittling effect of size has not been carried out to gage widths beyond one inch (generally because of the high cost of specimens, about $100-200 each), it is presumed that large forms may develop only a fraction of the ductility measured in a tensile test. Size effect studies for tensile tests (conduced by the author) have shown the occurrence of this phenomenon in three separate determinations for beryllium sheet produced by three techniques.

The potential value of beryllium in weapon systems structural components should be sufficient reason, in itself, for an intensive development program. With this development program, coupled with the advances which have been made recently in the beryllium technology, there is every reason to expect that beryllium will soon be classified as an important structural material.

A new division of
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Here's significant news for everyone who has an interest in metals and metal fabrication. The Dow Chemical Company, pioneer developers of Magnesium and Magnesium products, is now broadening its activities in metal working. A new division, THE DOW METAL PRODUCTS COMPANY, has been formed to specialize in the semi-fabrication and fabrication of not only Magnesium, but aluminum and other metals. This new division has excellent production facilities, plus knowledge gained through Dow's many years' experience in the metal working field. Facilities include plants for the manufacture of rolled and extruded products, sand and permanent mold castings, die castings, and fabricated assemblies.

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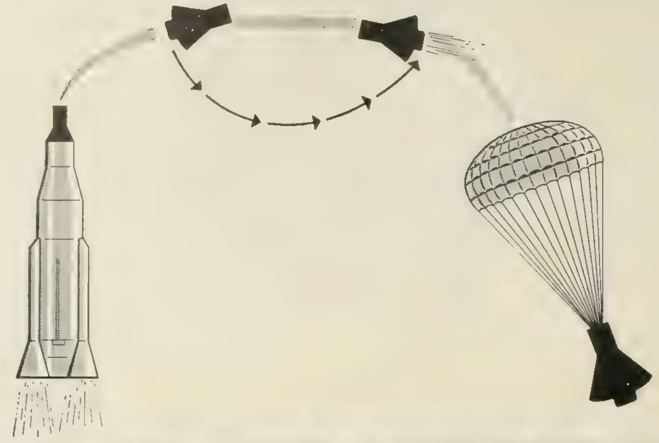

1. NASA flight plans call for ICBM-launching. The manned Mercury capsule will reach orbital velocity at about 120 miles, separate from the missile and ride horizontally in orbit.

2. Hurtling at 18,000 mph, the capsule will circle the earth in 90 minutes. Going into its re-entry phase, the capsule will be rotated by attitude controls to come "home" bottom down.

3. A drogue parachute will be deployed at 70,000 feet, decelerate the capsule and stabilize it. The final descent chute will be deployed at 10,000 feet preparatory for surface landing. Just prior to landing, pneumatic bags stored in the rim of the capsule will inflate to assure stability if landing is in water.

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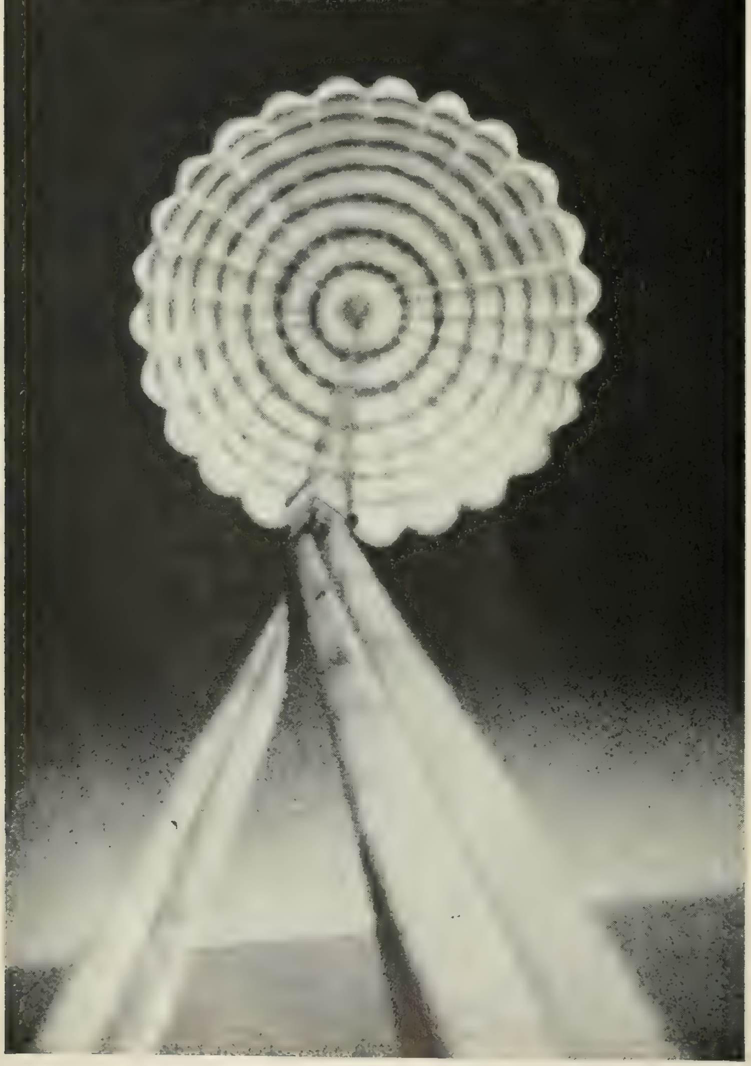

NEW TYPE OF RADIOPLANE PARACHUTE AN INTEGRAL PART OF NASA'S PLAN FOR RECOVERING FIRST MAN IN SPACE

The leader in the development, testing and manufacture of recovery systems – Radioplane–was selected by McDonnell Aircraft Corp. to join the National Aeronautics and Space Administration's Project Mercury.

Today Radioplane is readying the capsule landing system. For the project, Radioplane will use the new Ringsail parachute–a parachute with two radical departures from conventional Ringslot style. For a new kind of performance, Radioplane designed the new crescent-shape-slot parachute. The Ringsail withstands and reduces by as much as 35%, parachute opening shock at high-speed deployment. Drag coefficient and inherent stability are increased.

To solve the problem of aerodynamic heat without loss of strength, Radioplane is presently developing a high-temperature-tolerant fabric for drag devices.

This landing system for Project Mercury exemplifies Radioplane's unique capabilities. Scientists and engineers in Radioplane's Paradynamics Group combine their experience in the recovery field with the newest in equipment to develop systems with the highest degree of reliability. They are continually solving the increasingly complex recovery problems of the space age – producing the most efficient answers – at minimum cost.

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Space Temperatures Simulated in Chamber

One of the problems of the Space Age is development of materials that can withstand sudden and extreme temperature changes. Accompanying this is a need for equipment to test them.

Such a piece of equipment is the environmental chamber. This is a box-like unit in which temperature, air pressure and humidity can be carefully regulated to test airplane, missile and rocket components under conditions simulating those encountered in flight.

Recently the U.S. Navy asked **Webber Engineering Corp.** to develop a chamber that would test materials at 1000°F. This is hot enough to melt lead or zinc, and to consume a piece of cloth almost instantaneously.

Interior volume of the chamber was to be 27 cubic feet. Because of the heat extremes involved, heavy insulation between the inner and outer shells would be necessary. But if the insulating materials previously used for environmental chambers were employed, each wall would have to be 16 to 18 inches thick, drastically increasing the amount of floor space needed for equipment.

Webber's engineers found the reinforced insulating material needed in Foamsil, a light-weight, 99% pure fused silica foam developed by the **Pittsburgh Corning Corporation.** Tests proved that Foamsil could withstand up to 2200°F., 1200° above the Navy's specified ceiling. It also was tested successfully at 1500° for 96 hours and minus 2000 degrees for another 96 hours.

A shock test also was run, in which the temperature of the testing chamber was raised from 80 degrees ambient to 1000 degrees in 15 minutes. The level was then dropped to 100 below zero with no damage or breakdown in the insulating material.

Most important, it was determined that all the Navy's requirements could be met or surpassed by a chamber with Foamsil walls only six inches thick. These consisted of three layers of 17-inch by 22-inch by 2-inch blocks, bonded together and to the cabinet wall with a bonding material capable of withstanding the required temperature range.

The entire cabinet was insulated with Foamsil blocks, weighing a combined 945 pounds. Insulating cost was about one-fifth of that for a chamber with 18-inch walls of other available materials. In addition, a chamber with thicker walls would have required substantially more steel and additional labor to construct.

Foamsil also proved rugged and easy to handle. It has a compressive strength of 200 pounds per square inch, and it can be drilled, sawed or cut. It does not absorb moisture. As a result there was no condensation on the exterior of the chamber with low interior temperatures, and low transmission of heat to the exterior with high interior temperatures.

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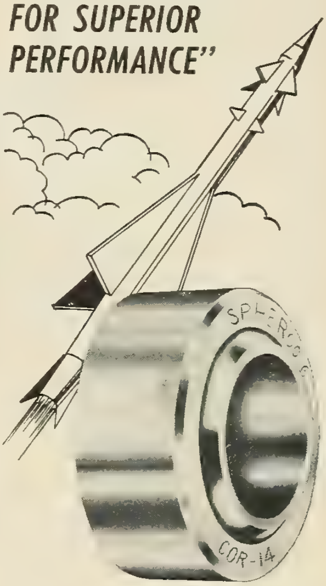

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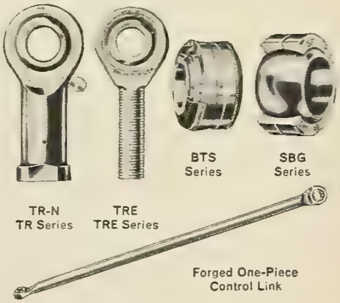

WRITE FOR BULLETIN 257

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5/8"	206	13.50	3.75
3/4"	144	10.50	4.25
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By using Foamsil, Webber Engineering was able to keep overall dimensions of the pilot unit, including refrigerating, heating and control equipment, to four feet by five feet by six and a half feet.

As the result of developing the chamber for the Navy, the Webber company has manufactured a standard model incorporating temperature extremes of 1000 degrees and minus 100 degrees with an altitude pressure testing to 100,000 feet and humidity control from 20 to 95% and relative humidity in the 35 to 185°F. range.

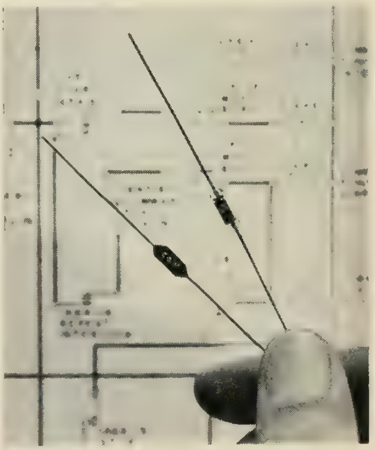
Circle No. 225 on Subscriber Service Card.

Oxide Film Resistors Made in 1/8 Watt Ratings

Oxide film resistors in new 1/8 watt ratings will be introduced by **Corning Glass Works** at the 1959 WESCON Show in San Francisco.

The new miniature components have been added to two lines of encapsulated resistors produced by Corning's Electronic Components Department at Bradford, Pa. Both the epoxy-coated N-60 resistor and the glass-enclosed NF-60 resistor conform to MIL-R-10509C, characteristic B.

The new units are the first 1/8 watt resistors to be made by Corning. They are approximately 3/8 inches in length and 1/8 inches in diameter.



The epoxy-coated resistor was introduced in ½ and ¼ watt sizes at the Radio Engineering Show in March. Its coating is said to provide excellent insulation and moisture resistance.

In the new 1/8 watt rating, as in the currently available ¼ watt size, its glass case is joined to the resistance element in a true glass-to-metal seal.

A UNIQUE APPROACH TO INFRARED GUIDANCE

This precision spherometer measures a unique material developed at Hughes for infrared guidance. It can measure the curvature of the dome's surface to an accuracy of 10^{-6} meters.

The material tested is unique in that it is completely opaque in the visible region, yet transmits very well in the infrared. First application of this material to military equipment requirements was carried out at Hughes.

This project is just one of the advanced studies in all phases of radar, inertial and infrared guidance currently underway at Hughes Research & Development Laboratories.

Assignments in missile guidance now open include:

Physicists to conduct Radiation Detector Studies
E.E.'s for Experimental Circuit Design
E.E.'s for IR Systems Studies
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Optical Designers

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Jack Lower, Chief of Gyro Design
Honeywell Aeronautical Division

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"The men I need to work with me are creative men—able to develop advanced concepts for gyros and to follow through on their projects. The work includes all areas of gyro design. It involves *precision gyro and accelerometer design, hydro-dynamic bearings, vibratory mechanisms, precision electric suspension techniques, gyro magnetics,* and *ferro-electric motors.*

"The people I want have a minimum of two years' (and up to twenty years') experience in such areas as *precision gyro mechanics, servo techniques, digital data handling, electronics packaging, advanced instrumentation,* or *magnetic component design.*

"If you are such a person, I'd like to hear from you. Just drop a line to my technical director, Mr. Bruce D. Wood, including pertinent information on your background, interests, and accomplishments. He'll arrange a meeting—to answer your questions—to discuss your plans and the possibility of a career with Honeywell."

Write: Bruce D. Wood, Technical Director, Dept. 850B.

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According to the company, this makes the components absolutely impervious to moisture.

Both new 1/8 watt units have a resistance range of 10 to 100,000 ohms at 250 volts and 70C, with derating to 150C.

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High Speed Digital Printer Transistorized

Potter Instrument Company, Inc., has announced the production of a high speed digital printer, Model 3303, completely transistorized and designed to be integrated into pre-flight checkout systems.

Built to conform to MIL-E-16400, the Model 3303 features print-out rates in excess of 10 lines per second and custom designed format with choice of number of columns up to 20 and type of characters or symbols.

Storage and programming electronics are offered in a separate housing that may be integrated with the printer onto a RETMA standard structure for rack mounting. Any character coding or single line control can be employed to control the printer.

Pressure sensitive paper is used to avoid the troubles usually experienced with ribbon and associated drive mechanisms.

Custom designs are available to satisfy specific system requirements. Physical dimension are: 8½" wide x 8" high x 15 7/8" long and 34 pounds in weight.

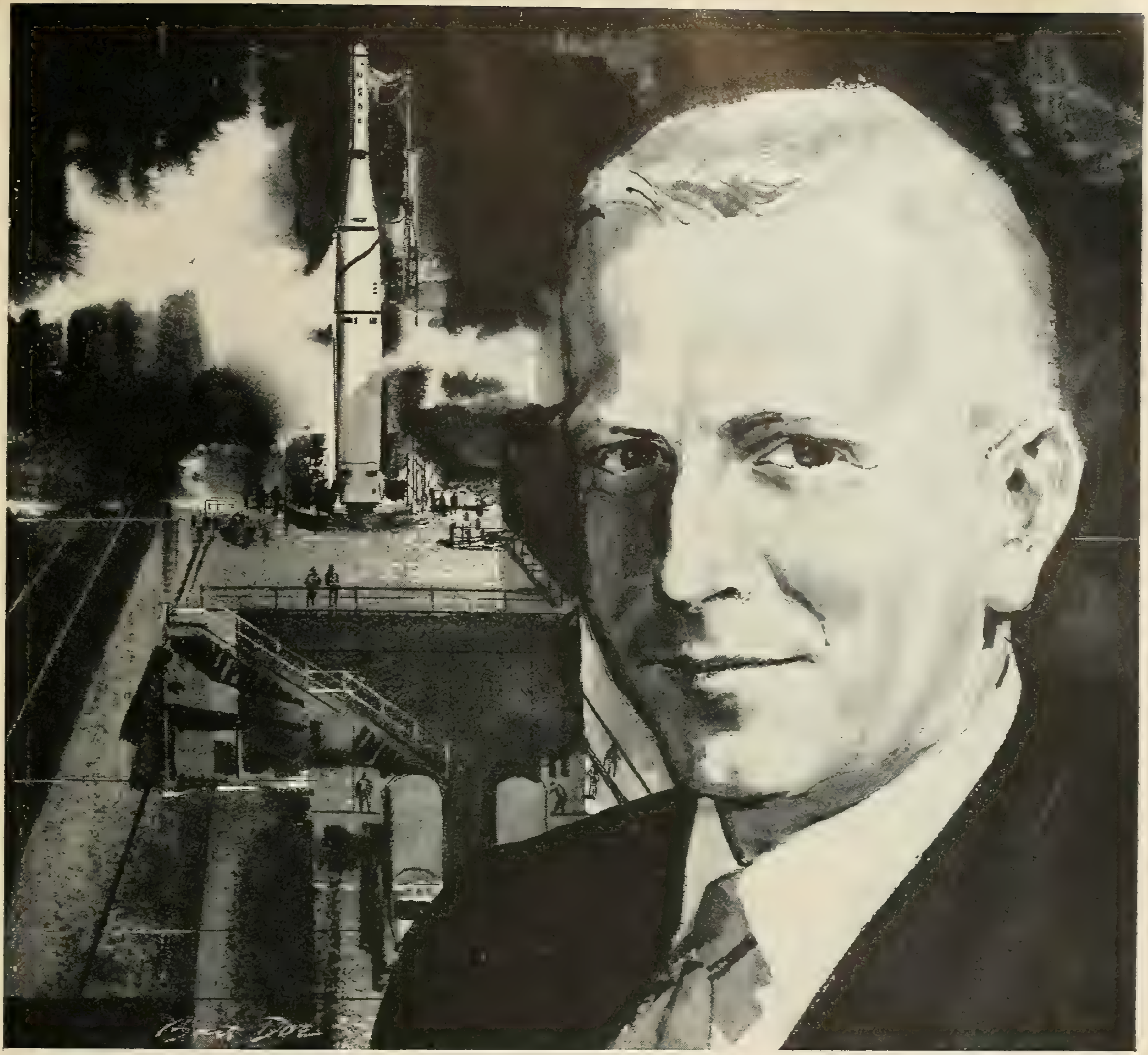
Circle No. 228 on Subscriber Service Card.

Line Shock Tester Costs Five Cents a Minute

Consolidated Electrodynamics Corporation, Rochester Div., has developed a compact shock tester which repeats either of a choice of two widely specified shock pulses in rapid succession.

Designed for on-the-line testing of high-volume production items, this new Hyge-6500 can perform a complete test cycle every minute. Unlike other units which require disassembly for a change of waveform, external adjustment permits change-over of the Hyge-6500 in just a minute or two.

Unit cost is kept low by limiting capability to the two shock test specifications most frequently encountered in volume production: MIL-E-5272A (11±1 ms Half-sine), and Ramo-



C. D. Boyce

October 1958, when the Thor-Able lunar probe soared 79,000 miles, was a time of quiet pride for Clay Boyce. Design engineer Boyce was responsible for successfully predicting the in-flight performance of the Aerojet second stage of the Able vehicle.

Clay Boyce has gone on to become an Aerojet Systems Division group leader, in charge of design and installation for the next generation of Able upper-stage vehicles for scientific and military applications. You'll agree, a mighty important assignment for a BSME still in his twenties.

Clay Boyce, with Aerojet since 1955, exemplifies the possibilities that exist at Aerojet for professionally gifted younger men to perform tasks of engrossing interest. We'd be delighted to hear from *you.* Write: Director of Scientific and Engineering Personnel, Box 296J, Azusa, California, or Box 1947J, Sacramento, California.

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THE S.S.White Industrial Airbrasive® Unit

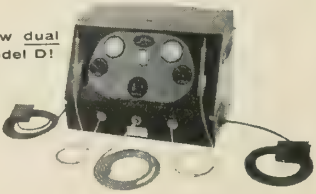
We don't recommend slicing up the family's fine Limoge China, but this does illustrate the precisely controlled cutting action of the S. S. White Airbrasive Unit. Note how clean the edge is, and how the delicate ceramic decoration is unharmed.

The secret of the Airbrasive is an accurate stream of non-toxic abrasive, gas-propelled through a small, easy-to-use nozzle. The result is a completely *cool* and *shockless* cutting or abrading of even the most fragile hard materials.

Airbrasive has amazing flexibility of operation in the lab or on an automated production line. Use the same tool to frost a large area *or* to make a cut as fine as .008"!... printed circuits... shaping and drilling of germanium and other crystals... deburring fine needles... cleaning off oxide coatings... wire-stripping potentiometers... engraving glass, minerals, ceramics. Jobs that were previously thought impossible are now being done.

Send us samples and specs on your difficult jobs and let us test them for you.

SEND FOR BULLETIN 5705A... complete information.



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Exclusive representatives for Arizona and California
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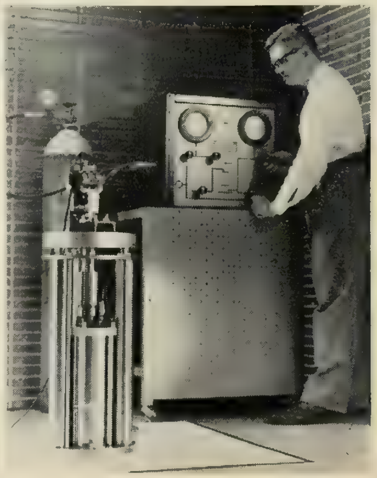
Wooldridge (6±.5 ms Sawtooth). Purchase price is less than that of other testers limited to a single waveform. Use of compressed bottled nitrogen as the power source keeps operating cost down to an average of 5¢ per test.

The Hyge-6500 tests specimens ranging in weight from a fraction of an ounce up to 150 pounds . . . from transistors to motor generators. Internal deceleration eliminates the need for rail systems, so that wide, bulky specimens can be easily accommodated on the specimen carriage. The carriage is 12½" in diameter, and 2" thick with a natural frequency of 2000 cycles. Fixture mounting holes are standardized with those used in shaker testing.

Acceleration level for the half-sine test is from 10g to 100g. For the sawtooth test the level is 25g to 100g. Like change of waveform, acceleration level can be varied by a fast, simple external adjustment. Maximum specimen thrust is 15,000 pounds, the product of the maximum specimen mass accommodated and the maximum acceleration level attainable.

Elimination of external braking devices such as rail systems makes this Hyge-6500 compact enough to be built right into production lines. Base is only 13" square, while height is not quite 30". Simplicity of operation permits use of inexperienced help. Operating safety is assured by automatic pressure bleed-off after firing, and by manual operation of toggle valve to rebuild pressure for the next shot.



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B.F.Goodrich

B. F. Goodrich Unilock Rivnuts® designed especially for aircraft and missiles

New lightweight steel Rivnuts with thread-locking feature preserve structural strength . . . save assembly time and costs

Ordinary anchor type fasteners used in aircraft and missiles require as many as three holes. And installation is made by two men who must have access to both sides of the work.

But new B. F. Goodrich Unilock Rivnuts can be installed by *one* man from *one* side of the work. Only one hole is needed. And the job can be done at any time during or after assembly.

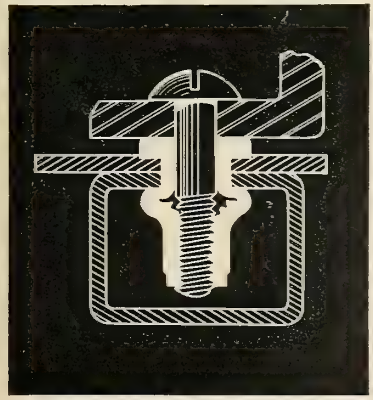
This greater flexibility in manufacturing procedure means a substantial savings in cost. In addition, with only one hole required instead of three, greater structural strength is maintained.

B.F.Goodrich Unilock Rivnuts, in fact, actually reinforce holes. That's because the equally spaced V-teeth under the Rivnut heads lock the Rivnuts to the material in which they are installed. This eliminates the need for a key and keyway—elements which ordinarily set up points of stress concentration.

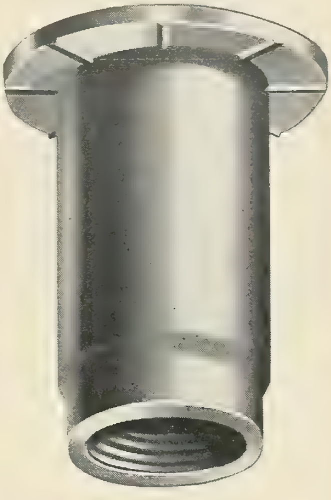
The thread-locking feature is a short crimp in the shank of B. F. Goodrich Unilock Rivnuts. This provides attaching screws with an all-metal interference fit that locks them securely in place.

Made from aircraft quality alloy steel, B. F. Goodrich Unilock Rivnuts are actually lighter than most anchor type fasteners. Yet they will meet strength and torque requirements of Military specification MIL-N-25027 for lock-type nuts.

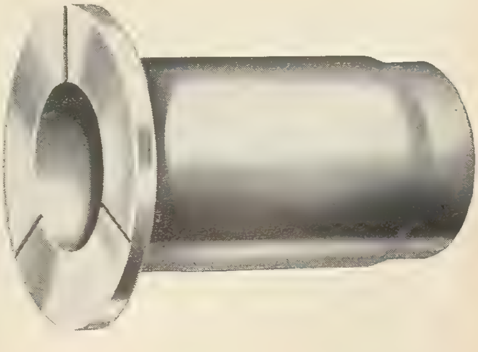
B. F. Goodrich engineers will be happy to make recommendations concerning the use of Unilock Rivnuts in your products. For complete information write *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MR-99, Akron, Ohio.*



Typical Unilock Rivnut installation in blind application. Installation principle is same as for regular Rivnuts.



B. F.Goodrich Unilock Rivnuts are basically the same in appearance and function as regular type Rivnuts. However, the Unilock design is identified by the V-teeth under the head and the crimped shank end which provides the thread-locking feature. Radial marks on top of the head readily indicate grip range.



Equally spaced V-teeth, made as an integral part of the under side of the head, engage with surface of material in which the Rivnut is installed, thus providing high torque resistance and eliminating need for keyed head and slot.

B.F.Goodrich ***aviation products***

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NEW VOUGHT PROJECTS
OFFER CAREER APPEAL
TO CREATIVE MEN

Space, ASW, and weapon system work at Vought requires continuous R & D in methods and materials, structures and design. These projects have prompted exploratory work in the following areas:

Structures
(Supersonic and Hypersonic)
Heat transfer, thermal stress and deflection analysis, and stress analysis using high-speed computers.

Manufacturing R & D
Welding and brazing of super alloys and exotics; advanced forming and cutting studies; prediction of metal fabricability.

Industrial Engineering
Project estimating, work sampling, line load and balance, and packaging and installation of new procedures.

Antisubmarine Warfare
Studies of detection and classification techniques involving Acoustics, Geomagnetism, Geophysics, Electromagnetics, Electrochemistry, Math.

Engineering Planning
Man-hour and budget forecasting, and project planning and scheduling.

Structures Materials
Advanced metallurgical analysis of exotic materials. High-temperature studies. Refractories, ceramics. Fusion welding of precipitating hardening stainless steels and tool steels.

Flight Test Instrumentation
R & D in new techniques for electronic gathering and reducing of flight test data.

Aerodynamics
Wind tunnel and model work employing Vought's 3,800-mph high-speed wind tunnel and new "high-temperature" laboratory.

Qualified applicants are invited to write:
Engineering Personnel
Dept. P-16

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propulsion engineering

By M/R STAFF

Better than molybdenum . . .

is molybdenum silicide (Mo_3Si). Chemists and metallurgists know that the compound is better than unalloyed molybdenum at high temperatures: the silicide retains its strength better and shows greater resistance to corrosion. The reasons for this are now being uncovered by Prof. Erwin Mueller (renowned as the pioneer in work with the field emission microscope) and his colleague at Pennsylvania State University, Dr. E. C. Cooper. The two are studying surface migration of atoms under a contract with the Air Force Office of Scientific Research.

Migration rate of atoms . . .

is much slower on the surface of molybdenum silicide than on the surface of pure molybdenum, when traces of oxygen are present. Mueller and Cooper believe this is related to the strength of the silicide in this way: Materials which are not readily deformed often are ones from which dislocations cannot be removed at the surface—a result of slow atom migration and rearrangement on the surface.

High-temperature strength . . .

of molybdenum silicide may depend on the presence of oxygen and its action in blocking surface migration, reports AFOSR's Solid State Sciences Directorate, which administers the Mueller contract. It says that when the last trace of oxygen was removed from the apparatus in which the Pennsylvania State team studied the metal and its alloy, "the migration rate on the silicide greatly increased until it equaled that on molybdenum."

The most important point . . .

made by the study, AFOSR concludes, is that the discovery "emphasizes the need for further studies of the properties of metals in ultrahigh vacuums where the absence of normally present contamination may alter important physical properties."

"It may develop . . .

for example," the office suggests, "that molybdenum silicide is weak rather than strong, in a good vacuum at high temperatures." The implication here is that a material we now regard as ideal for certain applications may fail us completely under some space conditions.

Solid propellants . . .

were the subject of another recent AFOSR activity. The classified (confidential) 15th Annual Meeting of the Joint Army-Navy-Air Force Solid Propellants Group, Washington, D.C., brought together 750 people. Most of them were from working levels of research and development on solid propellants. It was the largest meeting of its type ever held.

Some solid propellants contractors . . .

who attended the meeting and contributed papers: Dr. Raymond Friedman, **Atlantic Research Corp.;** Dr. R. F. Chaiken, **Aerojet-General;** and Prof. C. J. Marsel, New York University. All hold Air Force research contracts. What they discussed and what their prime interests are cannot be revealed. However, Friedman is one of the nation's leading authorities on flame and combustion. He held a $250,000 grant from the Air Pollution Foundation for basic studies on combustion which other chemists might someday apply to the problem of air pollution resulting from incomplete combustion in automobile engines. Marsel, a prominent chemical engineer, was one of the first persons to have wide knowledge of plans for chemical fuel (boron) operation of the B-70. Under AFOSR rules, their studies must be fundamental and out of the ordinary.

Red Astronauts Not Yet Chosen

from an m/r correspondent

London—Russia is planning several lunar probes soon but has not yet selected astronauts for her first manned space flights.

Furthermore, Academician Leonid Sedov told a news conference last week, Russia has not even fired a prototype of a manned capsule on a simple ballistic trajectory. This could indicate the Soviet "man in space" program is not ahead of America's Project *Mercury*.

Sedov, head of the three-man Soviet delegation to the annual congress of the International Astronautical Federation, agreed with NASA Deputy Administrator Hugh Dryden that international cooperation in space is very desirable. Sedov said his nation will cooperate with the U.S. in a major space exploration experiment or a series but the question should be settled first on the political level.

At the opening session of the conference attended by a record 600 delegates, Dryden declared that broad astronautics exploration is beyond the resources of any single nation and world cooperation is an immediate necessity.

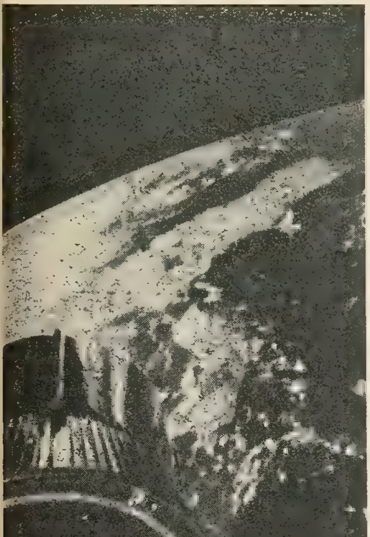
Americans again dominated the congress. The U.S. congressional delegation is reported headed for the Soviet Union next week to make an opening request for U.S.-U.S.S.R. astronautics cooperation.

Atlas Now Operational, Turned Over to SAC

Washington—The Air Force has quietly added the *Atlas* ICBM to its arsenal of operational weapons.

Air Force officials have disclosed that the big **Convair** missile was turned over to SAC at Vandenberg Air Force Base by ARDC on Aug. 31.

Defense Secretary Neil McElroy announced earlier this summer that *Atlas*' operational date had to be postponed until at least September because of technical difficulties. The Air Force has said the technical difficulties were solved and proved it by the recent series of successful *Atlas* firings from Cape Canaveral.



Atlas **RE-ENTRY vehicle looks back at Cape Canaveral shortly after separation from missile 295 seconds after lift-off Aug. 24. Florida east and west coasts run diagonally at upper right.**

U.K. Orders *Malkara* SSMs from Australia

London—A "substantial" order for the Australian *Malkara* SSM has been placed by the British Ministry of Supply. The *Malkara* thus becomes the British Army's first anti-tank guided weapon.

Thirty *Malkaras* have been delivered for acceptance trials and 150 are understood to have been ordered some months ago. The ministry did not make it clear whether the order referred to now is in addition to these.

The weapon has had extensive trials on the Ministry of Supply range in Kircudbrightshire. It is cruciform-winged and is controlled by wires. The *Malkara* uses a solid fuel rocket. It weighs 200 lbs., is about 6 feet long and has a range of about 3,500 yards. It was designed by the Government Aircraft Factories, near Melbourne.

NSF Awards Grants for Gas, Plasma Research

Cambridge, Mass.—Fundamental research in plasma dynamics at M. I. T. and high-temperature gas dynamics at Harvard will be sponsored under grants from the National Science Foundation.

Dr. William P. Allis of M. I. T. said a $500,000 grant will lead to increased knowledge of electric plasmas and their uses.

Dr. Howard W. Emmons of Harvard disclosed that the $300,000 grant will support research into behavior of gases at high temperatures.

A Special Memo
from
ROCKETDYNE
to a
PHYSICIST

Rocketdyne, the Nation's leader in Research & Development of high and low thrust propulsion systems has a position demanding

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AMC Ballistic Center In Major Shakeup

Major reorganization is underway at the AF Air Materiel Command Ballistic Missiles Center, Beverly Hills, Calif. The change involves establishment of several new directorates. One combines the formerly independent staff agencies for procurement, and for production, into a single procurement and production directorate under Col. Samuel W. Bishop.

Former independent weapon systems organizations for *Atlas, Titan, Thor* and *Minuteman* have been merged under a single directorate of ballistic missiles headed by Col. John A. Kewitt. Col. Sherman E. Ellis is commanding the new directorate of satellite and space systems, which encompasses the old directorate of satellite systems and special projects.

The directorates of sub-systems and resources are being regrouped into a single directorate of equipment and installations under Col. William W. Snavely. This organization will include the functions of resources, installations, guidance, propulsion and reentry vehicles.

The Air Force is pressing development of a large packaged liquid rocket engine. It has awarded a contract to **Thiokol Chemical Co.'s Reaction Motors Division**, Denville, N.J., calling for refinements in present packaged state-of-the-art. Thiokol's *Guardian I* and *Guardian II* packaged engines are used in the Navy's *Sparrow III* and *Bullpup* missiles.

Rare-earth oxides research is being extended to July, 1960, by the AF Office of Scientific Research. The program at Ohio State's Research Foundation is expected to add considerably to the field of materials for high-altitude and space flight.

Minuteman Nose Cone Contract Won by Avco

The Air Force has awarded **Avco Corp.'s** Research and Advanced Development Division, Wilmington, Mass., a $36.6 million prime contract to develop an ablative re-entry vehicle for the *Minuteman* ICBM. Avco, prime for the *Titan* nose cone, will also develop advanced materials for *Minuteman's* rocket motor nozzles.

Ford Motor Co.'s Aeronutronics Division has an ARDC contract to use its BIAX computer elements in developing an electronic "logical evaluator set" for selection and retrieval of information from a large magnetic tape file . . . The AMC is buying $5.2 million worth of APN-59 radar sets from **Sperry Gyroscope** . . . In the first half of 1959, ARDC centers awarded $29 million in contracts; of the 1038 contractors, 669 were classified as small business.

Expansions and Mergers

A $1-million missile/space R&D facility is being built by **Solar Aircraft Co.** at San Diego . . . **Wirepots Ltd.** of England, potentiometer producer, has been purchased by **General Controls Co.**, Burbank, Calif. . . . Latest addition to New Jersey's growing electronics industry is **Oliver-Shepherd Industries**—a new company which will employ 250 persons at Nutley.

Our most potent weapon in the battle of time:

QRC*

In advanced military electronics research, the ability to do the job *isn't good enough.* The job must be done *reliably* and *on time.*

Hallicrafters' QRC program was originated to provide not only the finest of engineering facilities and people, but the flexibility required for immediate, crash effort on critical electronics problems.

Hallicrafters has provided our military forces for the past six years with a Quick Reaction Capability that has played a major role in helping to win the battle against time.

* Quick Reaction Capability: Refer to Air Force Reg. No. 80-32

The tough jobs get off the ground in a hurry at . . .

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Chicago 24, Ill.

Qualified Engineers: new contracts have created openings. Contact William F. Frankart, Director of Engineering.

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west coast industry

By FRANK G. McGUIRE

The name **Astrodyne** will be dropped, now that **North American Aviation** is full owner of the solid-rocket producer. The company will henceforth be known as the solid rocket operation of **Rocketdyne Division,** and will be as much a part of Rocketdyne as the Neosho operations.

The recruiting of personnel . . .

has been growing in intensity and audacity among the talent-starved firms of the missile industry. Several instances pointed out at the recent WESCON show by Arthur Hoppe of the San Francisco *Chronicle,* are actually ironical and humorous . . . though expensive for Uncle Sam. He ultimately gets the recruiting bill, which is estimated at $2 billion annually.

The recruiting that went on at WESCON was described by one electronics executive as "the greatest white-slave market in the world." Techniques ranged from that of **Republic Aviation Corp.,** (which handed out Chinese fortune cookies advising "A brighter future can be yours with Republic . . . ") to that of the unnamed company which is reported to have bribed the hotel telephone operators to mis-route calls intended for rival recruiting suites. One firm, also nameless, handed this writer a pack of recruiting cards with the suggestion that they be passed out to promising young talent!

Of the WESCON Attendance . . .

one in twenty was estimated to be a recruiting agent, and one-third of the remainder were supposed to be looking for new jobs. The pickin's are conceded to be much better in the smog-ridden, overcrowded Los Angeles area than in the San Francisco Bay area. In order of apparent importance to available engineers are the type of job offered, local living conditions, and salary—which is now pretty well standardized in similar technical positions.

Probably the most ironical instance . . .

cited about the recruiting scramble is that of one electronics company executive who sadly related: "We sent ten strong, eager and dependable recruiters out to an electronics show in Chicago recently . . . and do you know—only four came back!"

The X-15's interim powerplant . . .

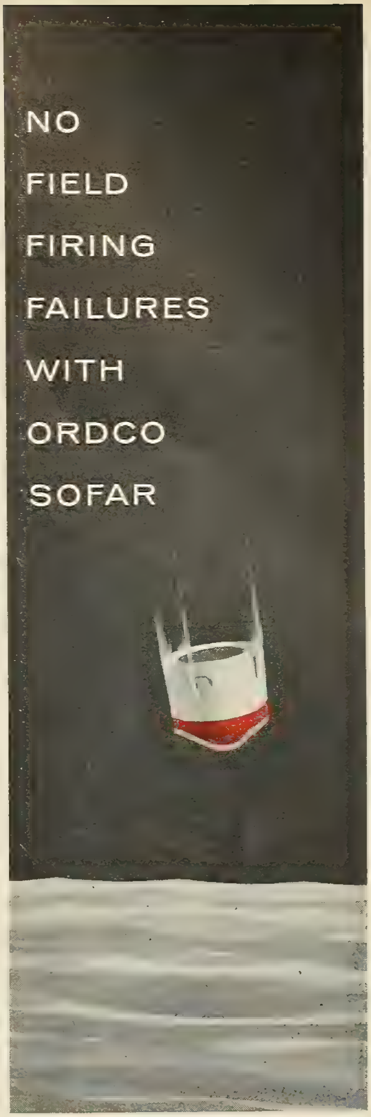
will probably remain "interim" for a long time. Many here hold that the single-barreled XLR-99 engine won't be ready even by the end of 1960, although some optimists expect delivery by the middle of the year. The research craft's present powerplant consists of two RMI XLR-11 engines, each with four nozzles developing 2000-pounds-thrust. The resulting 16,000 pounds thrust is one-fourth that of the XLR-99—a 50,000-pound-thrust engine. The XLR-11, incidentally, was first tested at Edwards AFB ten years ago as the first operation in the base's rocket test facility.

Production-line economy paid off . . .

for Uncle Sam in the T-33 jet trainer program just terminated at **Lockheed.** The aircraft, described as a "transistion trainer between yesterday's aircraft and tomorrow's spaceships," was reduced in cost so drastically that the final aircraft, No. 5691, cost 1/25 of the first. Another example, also at Lockheed, is that of a $10,000 annual saving through reduction of console-lights for electronic equipment from 150 types to four.

Consolidated Electrodynamics Corp. . . .

is in the strongest financial position in its 22-year history, the firm says. Sales, new orders and backlog for the first six months topped all similar periods for the company and its subsidiaries, while earnings after taxes were $858,844, topped only by the record first half of 1957. The CEC 4½%, 25-year, $7,616,500 convertible subordinated debenture issue was 96.61% subscribed through exercise of stockholder rights.



SOFAR

ORDCO Sound Fixing And Ranging devices—SOFAR—are engineered for no field firing failures. SOFAR units withstand water impact up to 70,000 Gs, arm at the correct depth and have fired with 100% reliability.

These SOFAR bombs, and related location-tracking equipment, have explosive charges ranging from .7 of a lb. to 10 lbs. Produced for the Armed Forces, they are the result of five years of ORDCO pioneering research and development.

ORDCO needs ordnance engineers. Please submit resumes to the chief engineer, Verne Luedloff.

ORDCO —reliable explosive-actuated devices made for the missile industry

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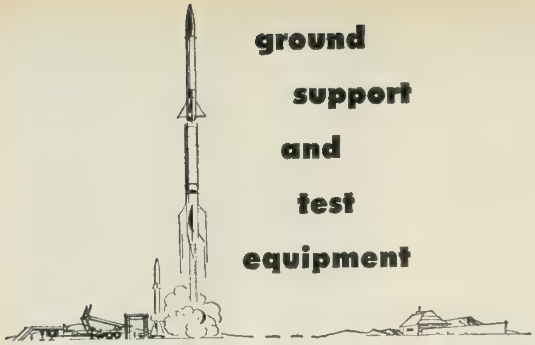
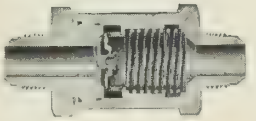


REPUBLIC VALVES



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No leakage. 3000 psi. Very low pressure drop. Can be furnished to open at ¼ to 35 psi. Brass, stainless steel, or aluminum alloy. ⅛″ to 2″ pipe or tube. Temp. range -65° to 200°F.

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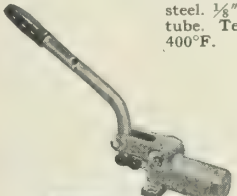
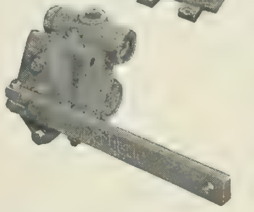
Quick unloading, smooth operation. Guided shut-off piston with stainless steel or Nylon seat. Pressure range to 4000 psi. Brass, aluminum alloy, or stainless steel. ⅛″ to ¾″ pipe or tube. Temp. range to 400°F.



HAND PUMP
For hydraulic applications on missile carrier and support equipment. Double-acting. 2 cu. in. displacement per cycle. 1000 psi. working pressure. Aluminum alloy body, stainless steel trim. -65° to 160°F.



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For automatically maintaining height and level condition in any vehicle with air spring suspension. Controls swaying in transit, and off-level position while standing. Applicable to trucks, buses, trailers, carriers, cranes, etc.

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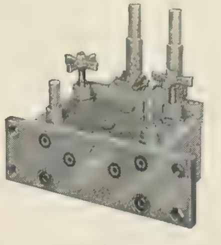

DUAL HAND PUMP
2 pumps, 2 relief valves, and 2 needle shut-off valves, compactly manifolded for elevating mechanisms, hydraulic applications on ground support equipment, etc. Aluminum alloy body, stainless steel trim. -65° to 160°F.

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contracts

MISCELLANEOUS

$8,500,000—**Bendix Aviation's System Division**, Ann Arbor, Mich., for development of communications subsystem for Project *Notus*.

$5,500,000—**General Electric, Missile & Space Vehicle Dept.**, for development of the satellite vehicle system for Project *Notus*.

$3,100,000—**Cornell Aeronautical Laboratory**, Buffalo, N.Y., for construction and operation of a wind tunnel for long-duration testing of hypersonic missiles.

$1,535,000—**Bell Aircraft Corp.**, Avionics Division, Buffalo, N.Y., for spare parts for a coder-decoder group used with radars to determine friend-or-foe.

$1,000,000—**General Dynamics Corp.**, for continuation of feasibility study of space vehicle propulsion through controlled nuclear pulses at John Jay Hopkins Laboratory for Pure and Applied Science, San Diego.

$117,000—**Northrop Corp., Radioplane Div.**, for development and production of four prototype recovery systems for the Mark 3C test vehicle. (Sub-contract from **General Electric's** Missile and Space Vehicle Dept.)

ARMY

$4,430,000—**Radio Corp. of America**, Moorestown, N.J., for UHF precision-tracking radar for *Nike-Zeus*.

$264,000—**Parabam, Inc.**, Hawthorne, Calif., for design and fabrication of 21 astrodome-type shelters for the protection of optical missile-tracking instruments. (Three contracts.)

$262,805—**General Electric Company**, Schenectady, N.Y., for electron tubes. (Two contracts.)

$191,151—**Steel Erectors, Inc.**, Savannah, Ga., for construction of radar tower, utilities and electrical distribution at Charleston AFB.

$64,932—**Kuthe Laboratories, Inc.**, Newark, N.J., for electron tubes.

$56,475—**Sylvania Electric Products, Inc.**, N.Y., for electron tubes.

$50,683—**Raytheon Co.**, Newton, Mass., for electron tubes.

$31,616—**International Telephone & Telegraph Corp.**, Clifton, N.J., for electron tubes.

$26,462—**Tung-Sol, Inc.**, Newark, N.J., for electron tubes.

$25,500—**Raytheon Co.**, Microwave & Power Tube Div., Waltham, Mass., for electron tubes.

AIR FORCE

General Electric Missile and Space Vehicle Dept., Philadelphia, has been awarded a contract for research and development of the re-entry vehicle or nose cone of the *XGAM-87A* missile. Amount not disclosed. (Subcontract from **Douglas Aircraft Co.**)

$9,000,000—**Burroughs Corp.**, for SAGE air defense units.

$1,750,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for additional guidance subsystems and parts for the GAM-72 *Quail* missile. (Subcontract from **McDonnell Aircraft Corp.**)

$1,365,343—**Canadian Commercial Corp.**, for 60 coordinate data monitors which decode telephone line signals from search radar.

$45,080—**American Institute for Research**, Pittsburgh, Pa., for investigation to determine optimal learning units and optimal presentations for use with automated instruction.

$26,101—Boston University, for research in statistical quantum mechanics.

$25,997—**University of Miami**, for continuation of research on Nuclear Emulsion Studies of Antiprotons, Strange Particles and K Meson Interactions.

$23,000—**Bogue Electric Manufacturing Co.**, Paterson, N.J., for development and production of ultrasonic continuous liquid level measuring equipment to control both liquid oxygen and liquid nitrogen level in a double dewar vessel, storing super cooled liquid oxygen.

when and where

AFOSR/Directorate of Aeronautical Sciences, Office of Naval Research National Science Foundation, Sixth Midwestern Conference on Fluid and Solid Mechanics, University of Texas, Austin, Sept. 9-11.

New York University's College of Engineering, Titanium Metallurgy Conference. For information: Dr. Harold Margolin, New York University, University Heights, New York, Sept. 14-15.

Society of Automotive Engineering, Display of USAF Ground Support Equipment for Manned and Unmanned Aerospace Vehicles, Milwaukee Arena, Milwaukee, Sept. 14-15.

Institute of the Aeronautical Sciences, Western Regional Meeting on Frontiers on Science and Engineering, Los Angeles, Sept. 16-17.

Army Signal Corp., Conference on Effects of Nuclear Radiation Semiconductors, Western Union Auditorium, New York, Sept. 17-18.

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CASTRUCCIO

Dr. Peter A. Castruccio, one of the country's foremost space scientists, has been elected technical director of the newly-formed Aerospace Division, Aeronca Manufacturing Corp. Dr. Castruccio has played a major role in the development of several military missiles and weapon systems. In 12 years with American industry, he has to his credit some 200 disclosures and about twenty patents pending or issued. He is on M/R's Editorial Advisory Board. **J. A. Wascavage,** formerly of Westinghouse Air Arm Division, has been named director of marketing of the new division.

James E. Veres has joined the staff of Summers Gyroscope Co.'s military relations department as senior applications engineer. Veres formerly was a sales engineer with Brush Instruments Division, Clevite Corp.

Filtron, Inc., has announced the appointment of five new engineers and scientists to staff positions in the Systems Division. The new associates are: **Kim R. Schuette,** former physicist with the National Bureau of Standards; **Denny Williams,** former chief engineer and consultant in radio interference suppression; **Clifford T. Culver,** formerly with Convair Astronautics Engineering; **George C. Stump, Jr.,** former senior engineer at Martin-Denver; and **Hollice Favors,** former project engineer on the AN/APQ53 project.

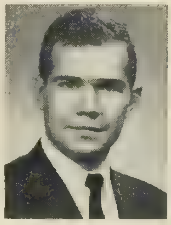
WHEELER

Harold A. Wheeler has been elected a vice president and director of Hazeltine Corp., producer of military electronics equipment. Wheeler worked with **Prof. Alan Hazeltine** on the original neutrodyne radio receiver, invented diode automatic volume control, and holds more than 150 patents.

Ronald Compton has been appointed senior engineer for computer design at Bendix Aviation Corp.'s Computer Division. Compton has been an associate engineer at the division and previously was affiliated with Librascope, Inc.

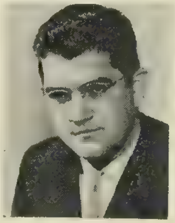
Rheem Semiconductor Corp., has named **David F. Brower** assistant manager of the engineering department. Brower for three years engaged in advanced research in the controlled thermonuclear research program of the General Atomic Division of General Dynamics Corp. and co-authored several research papers including "Atoms for Peace." He also holds several patents on fusion devices and allied components.

Dr. Alexander H. Flax, vice president and director of the Cornell Aeronautical Laboratory, has been appointed chief scientist of the Air Force. He will serve as scientific adviser to the Air Force Chief of Staff.



CRITTENDEN

General Electric has announced the appointment of **John R. Crittenden** as "severe environment specialist," a newly-created position in the company's receiving tube department. Crittenden will provide information on difficult environments in which electronic equipment must operate. Prior to joining the firm, he was associated with Chance Vought, where he worked on guidance system design for the *Regulus* missile. He also holds a patent application concerning a guidance system.



HALLOCK

Robert D. Hallock has been named manager of the Leach Corp. Inet Division, producer of ground power support equipment for commercial and military aircraft, missiles and space vehicles. Prior to joining the company he was staff engineer at Convair where he coordinated engineering and manufacturing activities on major missile projects. Other previous affiliations include: National Electronics, Acme Electronics Co., Bardwell and McAllister, Inc., Solar Mfg. Co. and Standard Coil Products Co.

Zembry P. Giddens has been named to the newly created post of executive vice president of Dynamics Corporation of America. Giddens previously held the position of assistant to the president and executive vice president of Electronic Switch and Signal Co. Before entering the electronics field, he was president of the Palmer Stendel Oil Company.

Glenn N. Hackett has been appointed to the newly created position of Director, Purchases and Traffic for Thompson Ramo Wooldridge Inc. He served in a similar capacity on the corporate staff of Thompson Products, Inc., prior to the merger with The Ramo-Wooldridge Corp.

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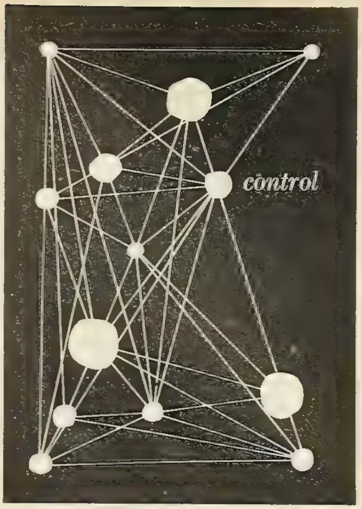

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The First Man on the Moon

The scientific community which deals in such matters, has, according to reports reaching us, divided into two camps and drawn sharp battle lines over a most unusual problem. Three years ago it would have sounded ridiculous, even today it sounds a little remote. But tomorrow it may be as pressing as the matter which Columbus took before Ferdinand and Isabella.

The problem? Whether space exploration should be done with men or with instruments.

One school of U.S. scientists maintains that most space exploration should be done with instruments, that men should be sent far aloft only after years of unmanned exploration. This group seems to be pretty much in command at the moment.

But there is another group pressing to be heard—a group which insists that we could learn much more about space environment, particularly our lunar satellite, and learn it sooner by using men.

Last week in London (M/R Aug. 31, Page 24) two champions of the bolder approach presented their views on manned lunar exploration at the annual Congress of the International Astronautical Federation. They were M. W. Rosen and F. C. Schwenk, who emphasized that their views did not necessarily represent those of their employer—the National Aeronautics and Space Administration.

They contended that because our knowledge of distant celestial bodies is so meagre the scientific community tends to magnify the importance of the simple data which can be obtained by instruments. Specifically:

"We overlook that, if an instrument can do one or several things, there are thousands, indeed millions, of things it cannot do. To put it bluntly, no instrument or array of instruments exist that can duplicate the sensing capabilities of a man. When to this is added man's capability to record, remember, interpret and discriminate, we see how paltry are the powers of the most sophisticated mechanical substitute."

They agree that there are a number of things man cannot do—see ultraviolet light, sense magnetic fields or detect cosmic rays, for instance—and that instruments have their purpose, with or without a man along. But they feel, and in this they undoubtedly will get plenty of popular support, that in the space race with Russia we haven't time for the waiting game; that while we are being cautious, bolder and braver men will be on the moon.

We agree with Messrs. Rosen and Schwenk, because in these days national prestige is of overriding importance. But we cannot escape the feeling that the entire matter is academic.

Man is born to explore, to dare the unknown. Just as he has always scaled the mysterious mountains and braved uncharted seas, so he will want to fly into space. Call it thirst for knowledge, quest for adventure, escape from the humdrum, search for glory, a contract with Life Magazine—man cannot face the unknown without wanting to know what in blazes is there.

So we suspect that mechanical progress and not policy will really solve the question of who is first on the moon. The nation which first produces a device capable of flying to the moon and back will also find men willing to ride in it—and a government willing to let them. And if the first man doesn't return—others will follow, for that's the way men are.

Need to Standardize

The recent word that studies are being made with a view to forming an industry-government group for coordination and standardization of missile telemetry (M/R, Aug. 24, Page 11) comes as welcome news and has already created considerable interest. The inadequacy of coordination between missile makers, instrument manufacturers and test ranges, and the lack of proper and authoritative standards, has been a basic fault of the U.S. missile program for a long time.

Maj. Gen. Donald N. Yates, commander of the Air Force Missile Test Center, only recently pointed out that there must be significant progress in range instrumentation—of which telemetering is a large part—if the ranges are to keep up with the advances which will come with second and third generation missiles.

This is a problem which affects the entire missile industry—one which should get the attention of both business and government. The early indications of strong interest in the formation of a coordinating group point up the fact that such a body is urgently needed—and has been for many years.

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ields for the T-3 ¼ lamp used in
ot Lights and other instrument light-
g are now in production by The Ama-
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ensing arrangement, the new tester
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lues to surface cleanliness where non-
nded soils are involved. For example,
e CM-1 will measure smut residue
ter pickling of steel. In addition, the
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nealing furnace performance; and 3)
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mined by O-ring seal. O-rings avail-
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d .05 mfd, 600 VDCW these units
asure only ⅞" in diameter and 15/64" thick. They wax to withstand extremes of temperatures and humidity. No. 22 tinned copper leads are 1½" long. Primarily designed for by-pass, coupling and filter applications, these "DD" series units are available from stock through electronic parts distributors. A separate group, the "ID" series, rated at 500 V.D.C.W. are available from parts distributors in industrial quantities only.

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TIME TOTALIZER. New Cramer Type 632 time-totalizers offer a simple, accurate means of recording elapsed time in industrial or laboratory operations. Time ranges available are seconds or tenths of seconds, minutes, tenths or hundredths of minutes, and hours, tenths or hundredths of hours. High torque instant start-stop motor drives a drum-type counter from the instant power is applied. External connections are easily arranged to operate the meter during equipment running time, idle time, or any operational phase. In all time ranges, the meters are available with or without reset, and in hermetically sealed cases designed to meet applicable specifications of MIL-E-5272A.

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TEMPERATURE INDICATORS. Accurate temperature measurements even at remote locations are said to be possible with Kahn and Company's Thermi-Tran Temperature Indicators. Thermi-Trans are designed for use with thermisters, which are inexpensive, thermally sensitive resistors having high negative coefficients of resistance. The high resistances of thermistors permit the use of ordinary copper wire leads of any practical length with negligible effect on accuracy of meter readings. This accuracy is plus or minus 2% of full scale. Coupled with the proper thermistor probes, Thermi-Trans can be used to measure temperatures of static or dynamic liquids, gases soft solids as well as surface temperature changes. Thermistors respond quickly to temperature changes and readings are practically instantaneous. There are two series of Thermi-Trans available. Series KC-532 is a single channel, portable unit which can be supplied with single or dual temperature range scales. Series KC-871 is a panel-mounted, multi-input unit with provision for up to six temperature sensing channels and single or dual temperature ranges.

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MISSILE LITERATURE

SOLID STATE CONVERTER. The Remington Rand Div. of the Sperry Rand Corp. has published a 12 page booklet describing the new Univac solid-state computer. Compatible to any punched-card installation, and representing a major breakthrough in the field of data-automation, this new system provides high-speed processing at relatively low cost, compactness, and unsurpassed accuracy and reliability. Advanced solid-state design is the difference. Because of tiny magnetic core amplifiers and transistors, it can be operated in an area as small as 575 square feet. These new devices emit very little heat, and power requirements are extremely low.

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SPRING CLUTCHES. The Marquette Division, Curtiss-Wright Corporation, Cleveland, Ohio, announced today publication of a new catalogue describing five standard lines of spring clutches in bore sizes from 1/8" to 1" and torque capacity up to 2500 pounds-inches. These spring clutches are specifically designed for use in machinery, equipment and instrument applications utilizing drive up to 5 hp. There are five basic series of clutches offered in the 30-plus page catalogue: Series A, Over-running and Back-stopping; Series B, Indexing; Series C, On-off; Series D, On-off Indexing; and Series E, Safety Lock Control.

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FACILITIES. United States Testing Company announces availability of a new six-page Bulletin 5902, describing the company's Materials Evaluation Division's facilities and services for analysis, development, research and inspection of materials and products. Among the services offered are metallurgical studies, metals chemistry, plastics evaluation, and physical testing. This work is done with the help of a complete range of analytical equipment, such as an X-ray diffraction unit, emission spectrograph, spectrophotometer, a variety of tensile and compression test units, heat treating furnaces, and the like. The tests and studies handled in the laboratory include: defect analysis, legal investigations, photomicroscopy, chemical analysis, physical and mechanical properties at sub- and supra-normal temperatures, air pollution surveys, and many others.

Circle No. 202 on Subscriber Service Card.

WIRING HARNESSES. Methods, Inc., has published a 14-page booklet of key points in the design, manufacture, and use of wiring harnesses. It contains many practical hints for improving stripping, tinning, soldering, etc. of cable wires, and suggests design procedures for facilitating in-the-instrument connecting operations and ways for the harness user to plan, simplify and improve cable installations. Also delineated are ways for stepping up speed and accuracy of inspection. Line drawings are used throughout to illustrate techniques.

Circle No. 203 on Subscriber Service Card.

SOLDERING MANUAL. The American Welding Society has announced publication of the first manual on soldering ever published. Containing 176 pages, 81 illustrations and 34 tables, the book completely covers all phases of soldering, combining the theoretical with the practical. The twenty-one chapters deal with the following subjects: principl of soldering; solders; fluxes; joint d sign; precleaning and surface prepar tion; equipment, processes and proc dures; flux residue treatment; inspecti and testing; copper and copper allo steel; coated steels; stainless stee nickel and high-nickel alloys; lead a lead alloys; aluminum and alumin alloys; magnesium and magnesium allo tin; cast irons; precious metal coatin printed circuits; and safety.

Circle No. 204 on Subscriber Service Ca

MICROWAVE METERS. A new 12-pa catalog with complete technical d on a line of microwave meters a filters is available from Frequen Standards. The catalog includes pre sion frequency meters in the 500-180 mc tuning range and tunable band p filters with tuning ranges from 960 9600 mc. General design data cover cavity types, and frequency response a insertion loss information on filters included, together with frequency—kr dissipation loss-db, and rejection— curves.

Circle No. 205 on Subscriber Service C

PLASTIC RESINS. A technical bulle describing the properties of reinfor plastic resin systems as ablation r terials for re-entry into the earth's atm phere has been published by Zer Plastics, Co. Designated as Technical letin #2.15, the report covers a resu of general results obtained in a se of tests using variations of "Scotchp brand reinforced plastic.

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POWER SUPPLIES. Sixty-three high-v age dc power supply models are scribed along with tabular specificati in a new "HV DC" product data sh now available from Sorensen and C pany. Data is given on the new Soren P, MP, HP and VHP Series high-v age supplies as well as on the 1000 2000 Series high-voltage supplies. M mum output voltage ratings comple cover the range from 1 to 350 kilov Nominal maximum output powers ra up to 60 kilowatts. Recommended plications include: dc dielectric test capacitor charging, injection and fo ing sources for nuclear particle accel tors, electrostatic precipitation and eration, vacuum tube testing, and m similar applications.

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TURBINE GRINDER. A new low c 12½ oz. light duty turbine grinder m by Desoutter Brothers Ltd., Engl now being distributed throughout U.S. by Newage Industries, is descri in a booklet offered by the distrib The new grinder uses a "balanced sign body for comfortable handling comes complete in a fitted wooden c with 6 mounted grinding wheels, c spanners, a hed spanner, 10' of 3/8" with two connectors, jet plates an dressing stone. It is guaranteed fo months. The grinder runs cool, blo chips away from work, and feat automatic air shut-off when it is dis nected. It is specially designed for and die makers requiring a grinder intricate hand work. The Desoutter 000 rpm turbine '03' grinder grinds, burrs, cuts, polishes, and engraves

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MISSILES AND ROCKETS

SEPT. 7, 1959

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He smashed the sound-in-water barrier

Because its energy passes only through air, radar can pick up targets hundreds of miles away. The ocean isn't so cooperative: water rapidly absorbs all types of energy. How do you breach this barrier to produce a really long-range underwater surveillance system?

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SEPTEMBER 14, 1959

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Peaceful Gains from Cold War R&D 13
The Surge of Microminiaturization 18
Reliability Drive Gains Momentum 28

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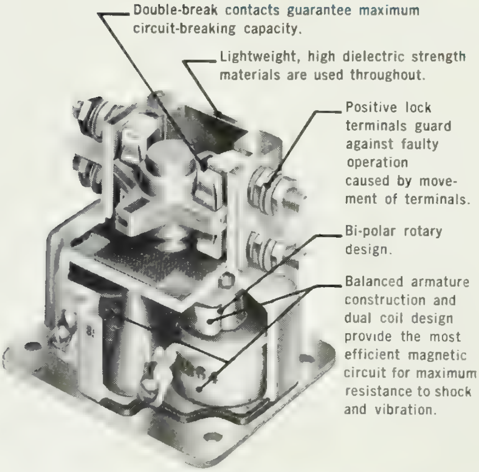
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GENERAL ELECTRIC

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missiles and rockets ®

MAGAZINE OF WORLD ASTRONAUTICS

SEPTEMBER 14 HEADLINES

Missile/Space Spending Yields Peacetime Dividends
A preliminary survey based on M/R questionnaires sent to hundreds of companies shows that the nation is already gaining new goods, techniques and industries from its investment in Cold War research and development 13

IAF Congress Hears Papers Covering the Space Field
A special service: abstracts from some of the most significant papers at the recent London meeting; emphasis on space medicine and magnetohydrodynamics 37

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Microminiaturization—A Revolution is Well Under Way
A report on the dramatic development of a concept that will be here in full force in about two years, saving millions of dollars and enhancing reliability 18

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U. S. Reg. Pdg.

New Impetus Is Given to Drive for Reliability
Military services plan to step up use of off-the-shelf components; NASA will stretch out firing schedules in effort to raise its batting average 28

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A Picture Report on Thiokol's Utah Division
Huge solid-propellant plant, less than two years old, sprawls over 11,000 acres, is 40% Air Force-owned 32

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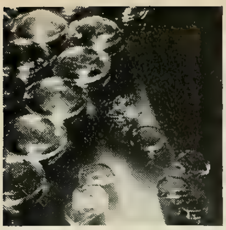
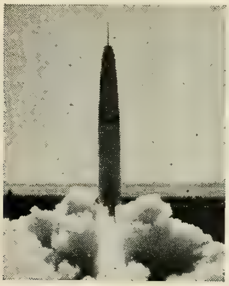
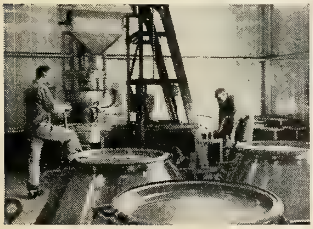


COVER: Mass production of optical glass, developed for military by Corning Glass, provides high-quality, low-cost spectacles for millions. Survey of non-war uses of R&D starts on p. 13.

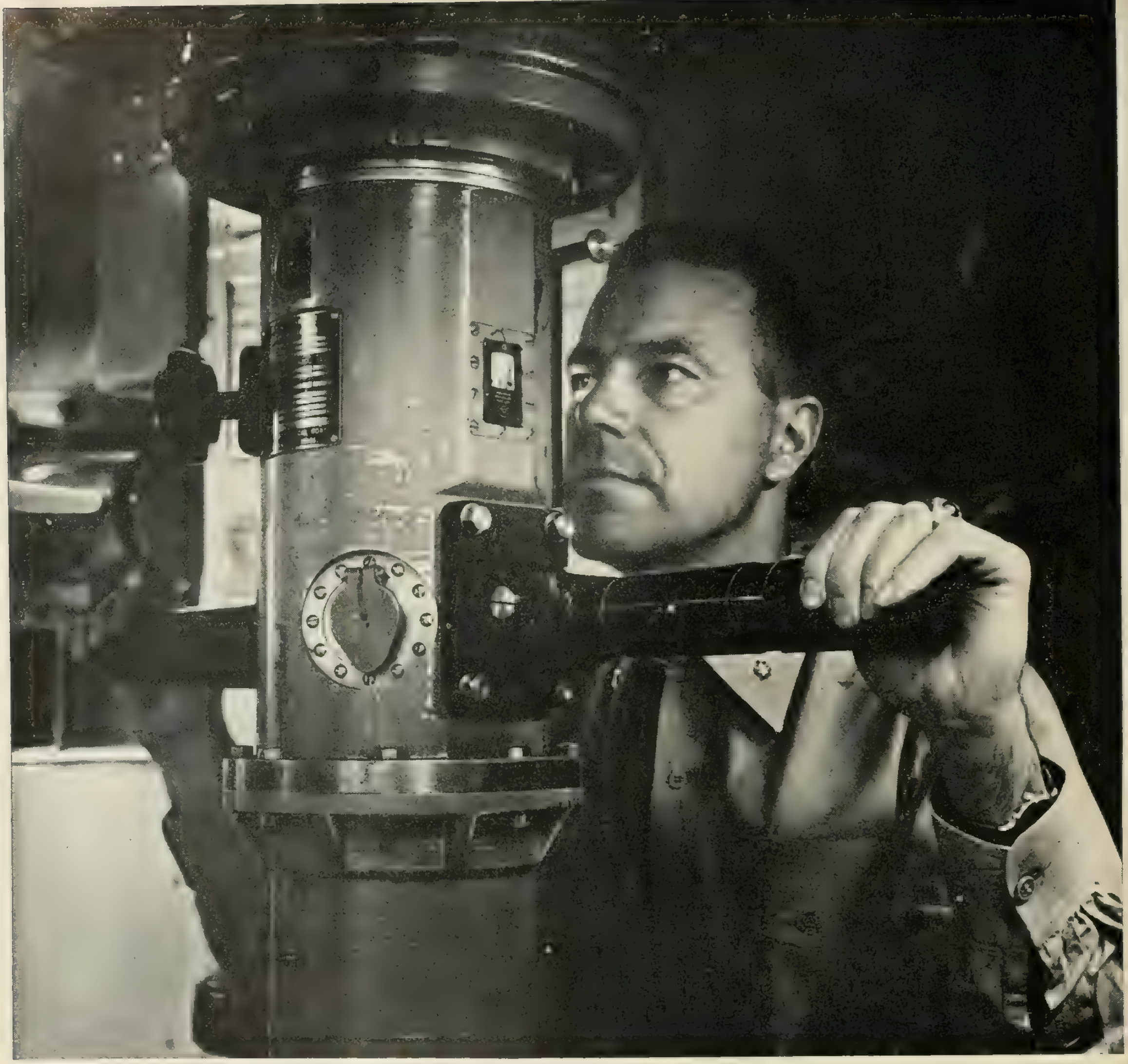
OPERATING micro-module made by RCA under contract for the Army. Nearly 100 companies so far have taken part in the R&D of micro miniaturization. A progress report starts on p. 18.



RELIABLE *Thor* rises from Cape Canaveral. The urgent need for better reliability of components and the steps that are being taken to achieve it are reported in story beginning on p. 28.



OXIDIZER is reduced to size in this grinder and gyratory sifting machine at Thiokol Chemical Corp.'s Utah Division, Brigham City, Utah. For a picture report on work at the new division, see pp. 32 & 33.



COUNTDOWN...at full fathom five

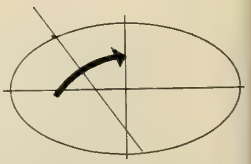
One day, a new fleet weapon system will be *on-station* beneath the ocean surface—ready to hurl retaliatory missiles toward strategic inland targets with pinpoint accuracy. This new weapon system will be part of the Navy's Polaris Fleet Ballistic Missile Program.

Though new in concept, the Polaris program makes full use of the precision Shipboard Inertial Navigation Systems (SINS) developed and produced by Autonetics for the United States Navy.

System design and components of earlier autonavigators have proved reliable in an Air Force supersonic missile, aboard the Navy's surface ship *USS Compass Island,* and on the *USS Nautilus* and *Skate.*

Advanced Autonetics' Shipboard Inertial Navigation Systems—like those to be used by the *USS George Washington,* the first Polaris-carrying submarine—will provide the critical missile alignment data to insure effective missile launching. SINS emits no tell-tale signals ...requires no receipt of external transmission at any time.

DID YOU KNOW?



The flattening of the earth at the poles can result in a navigational error of almost eleven nautical miles if not taken into account.

Inertial navigation by Autonetics

A DIVISION OF NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA • REGIONAL OFFICES: WASHINGTON, D.C. AND DAYTON, OHIO
INERTIAL NAVIGATION/ARMAMENT CONTROL/FLIGHT CONTROL/COMPUTERS AND DATA PROCESSING

Washington Countdown

IN THE PENTAGON

Transit will go . . .

into orbit within the very near future if the present ARPA-Navy schedule is followed. Plans call for launching the first U.S. navigational satellite with a **Douglas** *Thor* booster.

• • •

Minuteman would roll . . .

over the nation's western wastelands under Air Force plans now being considered. The **Boeing** solid ICBM's would be mounted on big trucks which would roam empty Federal-owned lands, preventing Russia from zeroing in its missiles on them. The *Minuteman* could be fired from the trucks.

• • •

The price of survival . . .

according to Gen. Thomas Power, SAC commander: Dispersion and hardening of missile and bomber bases, secure communications, a constantly ready alert system and defense against sabotage.

• • •

The threat of sabotage . . .

incidentally, is putting many a gray hair on the heads of SAC security officers as ICBM bases become a reality. The big ICBM's are particularly vulnerable to simple methods of sabotage. One shot from a .22 calibre rifle, for instance.

• • •

Music to launch by . . .

is considered "a must" for hardened ICBM bases. Air Force psychologists say music should be piped into underground missile sites to prevent missile "molemen" from losing their efficiency because of monotony.

• • •

A new secrecy gimmick . . .

for withholding information in the Pentagon is said to be tripping up missile industry officials. It's reported that unclassified material is being withheld by labeling it "not releasable."

• • •

The battle of the B-70 . . .

is looming. Air Force commanders are braced for an all-out fight to save the **North American** Mach 3 bomber and its fighter companion—the F-108—from the budget ax. The B-70 would carry the **Douglas** *ALBM*. The F-108 would be used to defend the United States against the Soviet counterparts of the futuristic bomber and missile.

ON CAPITOL HILL

Anti-influence legislation . . .

will accompany the report of the Hébert Subcommittee on its lengthy investigation of the so-called munitions lobby. The subcommittee plans to meet in late November to write its recommendations. The report and legislation will follow—probably just before Christmas.

• • •

A few more hearings . . .

by the Hébert subcommittee will be held during the fall to take care of some loose ends. But for the most part the public hearings are ended. This is a switch from previous subcommittee plans to hold some finger-pointing hearings in early December.

AT NASA

Equatorial launching range . . .

plans have reached the stage where NASA is expected soon to ask for bids for construction of tracking and launching facilities. The proposal is expected to place the launching site at Manus Island in the western Pacific (M/R, May 18). The contract probably will be let next spring.

• • •

Silent sound sickness . . .

is a new perile of the Missile Age. Scientists have found that "silent" high-frequency sounds given off by large rocket space vehicle boosters may injure the health of launching crews. The sounds have been found to cause stomach ulcers and reproductive disorders in animals. NASA is trying to come up with effective mufflers for the big rockets.

AROUND TOWN

A Nipponese missile navy . . .

may be in the offing in the Far East. The Japanese are reported to be planning to begin it with construction of a missile destroyer. It would be armed with surface-to-air missiles—maybe **Convair** *Terriers*.

• • •

Some other reports . . .

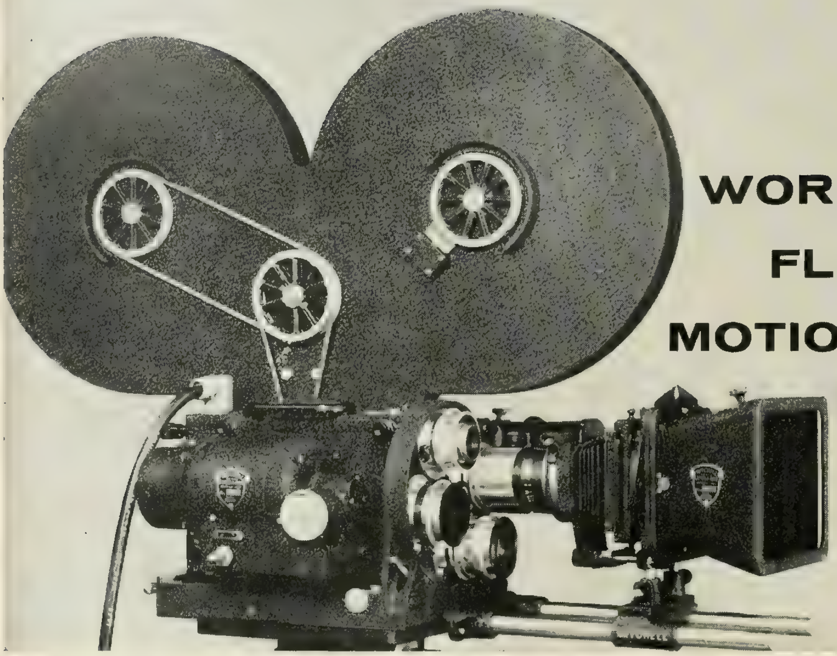
being passed as "the latest" in the nation's capital:

. . . Defense Secretary Neil H. McElroy is planning to resign by Jan. 1, at the latest.

. . . NASA Chief T. Keith Glennan will stick out the Eisenhower Administration in his post despite rumors that he also will resign soon.

. . . Western Europe wants to confine its space programs at least for the present to R&D.

WORLD'S MOST FLEXIBLE MOTION PICTURE CAMERA



Mitchell camera shown with 1200′ magazine.

MITCHELL

No other motion picture camera is today used for such a broad range of exacting film making as is the Mitchell. The versatile speed of the camera, ranging from 1 to 128 frames per second, plus 14 exclusive features equip the Mitchell for an impressively broad range of cinematography. A single Mitchell can meet the requirements for finest quality TV commercials, feature productions, public relations, sales and training films, progress and report films, plus critical research and development data and record photography.

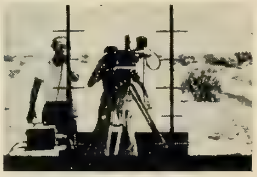
Mitchell cameras include: 35mm and 16mm cameras; 70mm 2¼ x 2¼ high speed cameras; and 70mm, 65mm and standard aperture cameras.

For information, write on your letterhead—please indicate which model camera your request concerns.

GENERAL ELECTRIC uses Mitchell for wide range of work, including slide films.

BUD WILKINSON PRODUCTIONS shoots its award-winning TV Sports Series with the Mitchell.

KEARNEY & TRECKER films first fully automated tape controlled combination machine tool with the firm's Mitchell camera.



LOCKHEED AIRCRAFT CORP., uses Mitchells continuously throughout plant, here records jet flight.

**85% of All Professional Motion Pictures Shown Throughout the World Are Filmed with Mitchell Cameras*

Mitchell Camera Corporation, 666 West Harvard Street, Glendale 4, California

Industry Countdown

MANUFACTURING

Competitor to NASA's *Scout* . . .

space vehicle is being pushed by **Grand Central Rocket Co.** The all-solid three-stage GCR *Envoy* would cost $300,000 per flight vs. $500,000 for *Scout*. *Envoy* would be 37.8 feet high, weigh 17,000 pounds and be capable of sending a 50-pound payload to the moon or orbiting 230 pounds at 300 miles . . . GCR also is developing a high mass ratio solid motor for NASA called "Wolf" which the company expects will "revolutionize the satellite launching technology." Object: cheaper upper stage rockets.

• • •

Inside AF pressure . . .

for more spending on the **North American** air-to-surface *Hound Dog* is being stepped up. This bird may be the mainstay of AF "missile mobility" until it gets the long-range **Douglas** ALBM.

• • •

Dyna-Soar contract decision . . .

is still four or five weeks away while ARDC takes more "long looks" at booster designs of competing **Boeing** and **Martin-Bell** teams. Summer-long delay in making the R&D award also is attributable in part to forthcoming ARDC reorganization and possible policy change wherein AF procurement officers would have greater in-house management capability and responsibility.

• • •

Women's underwear mesh . . .

nylon closure may be the answer to weightless walking. USAF space medicine chief Col. John T. Stapp told M/R at London IAF Congress his team is testing out "Velcro" as substitute for suction cups or magnets. The material consists of thousands of small nylon fishhooks which interlock as strong as a zipper when pushed together, and are easily disengaged. The idea is to line the interior of a space ship with the material and also the soles of the spaceman's shoes so he can obtain traction.

PROPULSION

New high-thrust fuel . . .

has been patented by **Dow Chemical.** It's a mixture of an oxidizer and 2-propynyl hydrazine. The compounds 1,1-bis (2-propynyl) hydrazine, 1 methyl-(2-propynyl) hydrazine, 1-ethyl 1 (2-propynyl) amine, dimethyl (2-propynyl) amine, and allyl (2-propynyl) amine are also claimed as alternatives within the invention.

Big boost for composites . . .

is seen in 15% price slash on ammonium perchlorate—most widely used solid rocket oxidizer. **American Potash and Chemical Corp.,** principal AP producer, last week cut its quotation from 34 to 29 cents per pound FOB Henderson, Nev. Missile programs will use between 9000 and 15,000 tons of AP this year; thus the price cut may mean a saving of about $1 million.

ASTRIONICS

High-density pulse-packing . . .

techniques in a lightweight magnetic tape recorder are reported successful in a new system devised by **Consolidated Electrodynamics** and **Douglas Aircraft.** The 100-pound digital recorder handles 1500 bits/in. on each of 16 tracks. With 1-inch tape this provides total capacity of 2.4 x 10^9 bits.

• • •

System can sample . . .

100 primary channels each at a frequency response of 100 cps for a one-hour test. It is designed for PCM/FM telemetry compatibility.

SPACE MEDICINE

Men garbed in coveralls . . .

have survived five minutes in an oven with the air temperature at 300°F and the walls at 500°F in new tests of human endurance. Tests now also show the body can withstand 16.1 g's for 15 seconds during 4-minute run-up and back with the subject supine and without a water jacket.

WE HEAR THAT—

AC Sparkplug is readying . . .

a major plant expansion at Milwaukee and Flint. The company will add nearly a quarter-million square feet to consolidate its defense engineering facilities under one roof at Milwaukee . . . **Space Technology Laboratories** is officially denying rumors that it is about to be bought by **Ford Motor Co.** . . . However, it is known **Twin Coach's Aircraft-Missiles Division** is in the market for acquisitions and mergers . . . Anticipating a big increase in space/missile beryllium usage, **Beryllium Corp.** is expanding its Hazleton, Pa., facility to install three vacuum hot press furnaces to produce billets from 6 to 45 inches in diameter and up to 60 inches long.

More About the Missile Week on Page 44

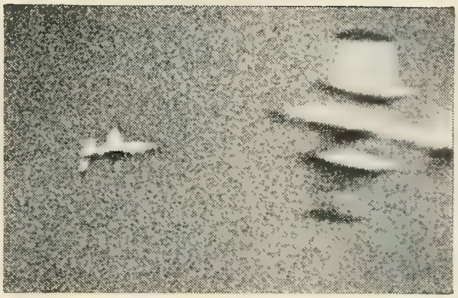
HOW BLOODHOUND
FOR

WEAPON DESIGN AND CONSTRUCTION BY BRISTOL · GUIDANCE AND CONTROL BY FERRAN

PROVIDES

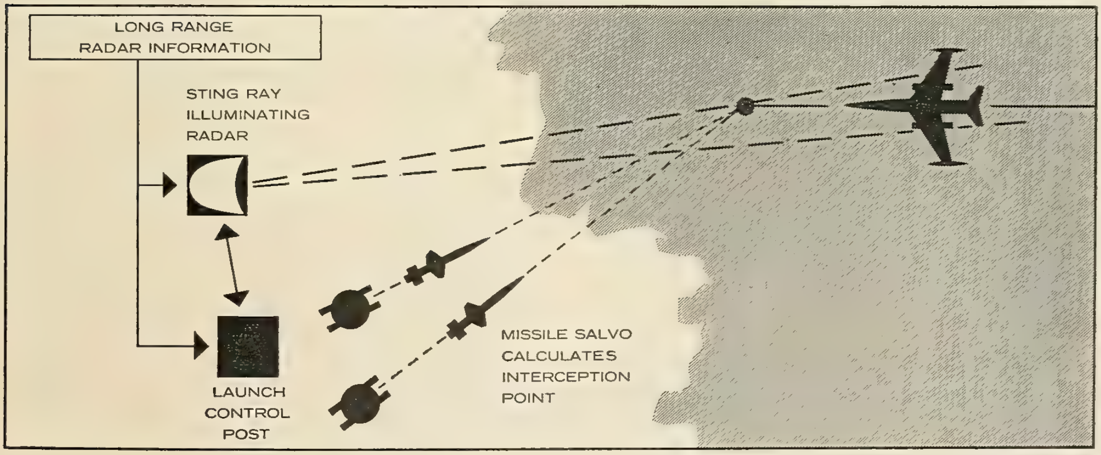
DEFENCE

Surface-to-air guided missiles represent the most important advance in defence against air attack since aerial aggression began. These unmanned interceptors are not committed to a predetermined course, but, even after launching, take corrective action against target aircraft evasion.



READY NOW

The World's most effective surface-to-air guided missile system is Bloodhound. Already in operational service with the RAF and adopted by non-NATO Sweden. Bloodhound is now to be further developed for the RAF. Bloodhound has been proved in many hundreds of test firings. It exists for defence—*now.*


LONG RANGE RADAR INFORMATION
STING RAY ILLUMINATING RADAR
LAUNCH CONTROL POST
MISSILE SALVO CALCULATES INTERCEPTION POINT

WHAT BLOODHOUND PROVIDES

By using radar intelligence, enemy aircraft may be allocated for interception either to Bloodhound missiles or to manned fighters.

Essentially a deterrent designed to frustrate not to initiate aggression, Bloodhound contributes to air defence the advantages of very effective high fire power which is always available for action at a moment's notice. And the development of Bloodhound is still in its infancy.

Now—and for many years to come—Bloodhound provides the world with its most impregnable defence system.

BRISTOL/FERRANTI
Bloodhound
GUIDED WEAPON SYSTEM

RGET ILLUMINATING RADAR BY BTH · SYSTEM SALES ORGANISATION BY BRISTOL AIRCRAFT LIMITED

MOVING AHEAD----

"TO PROVIDE FOR THE COMMON DEFENSE"

Only by conceiving today the weapons which will be needed tomorrow; can the free world continue to preserve the peace—or successfully meet an attack.

TIME IS OF THE ESSENCE!

ANOTHER STEP FORWARD

To cope successfully with this urgent and continuing problem, RCA recently extended to a corporate-wide basis the techniques which had been proven successful within its various departments, by creating an *Advanced Military Systems* organization at Princeton, New Jersey. There, in an atmosphere of intellectual freedom, a group of mature scientists and engineers are engaged in the analysis and study of our national defenses—present and future—and how they can be made most effective to meet any future enemy capability.

These studies are conducted at the frontiers of knowledge and encompass such areas as the physical and engineering sciences, military science, economics, and geophysics. Studies have, as an end result, the creation of military systems which will satisfy projected military requirements.

A SPECIAL KIND OF MAN

Members of the technical staff are at the highest creative and intellectual level. They have a degree of maturity which comes only with many years of experience. They generally have held responsible positions in research, advanced development, or systems planning. Most of them have an extensive background in the broad fields of electronics, vehicle dynamics, physics (astro, nuclear, or plasma), or military science (operations research). All are temperamentally suited for performing highly sophisticated, comprehensive analysis and planning of a detailed nature. They are men who enjoy seeing the fruits of their work turn into realities that have an extensive effect on the defenses of the country.

A SPECIAL KIND OF CLIMATE

Each member of the technical staff operates either independently or in a loosely organized group, and is generally free to select his own area of work. The only condition: results must have a direct application to problems of national defense. He has no responsibility for administrative details, although he must be ready to give guidance to program implementation. He can call in any specialists he may need. He has full access to all available information—military, academic and industrial. Specialized research projects and laboratory work can be carried out at his request by other departments of RCA. In a word, he is provided with every opportunity and facility to use his creative and analytical skills to maximum advantage and at the highest level.

A SPECIAL KIND OF ENVIRONMENT

Princeton offers unique civic, cultural and educational advantages along with the convenience of its proximity to New York City. In this pleasant environment, Advanced Military Systems occupies a new, air-conditioned building on the quiet, spacious grounds of RCA's David Sarnoff Research Center. Working in individual, well-furnished offices, staff members find their total environment highly conducive to creative activity.

INQUIRIES ARE INVITED

If you are interested in learning more about this far-reaching program, write:

Dr. N. I. Korman, Director,
Advanced Military Systems, Dept. AM-11
RADIO CORPORATION OF AMERICA,
Princeton, New Jersey.

EQUAL JOB OPPORTUNITY
For All Qualified Applicants

RADIO CORPORATION of AMERICA

How Missile/Space Spending Enriches the Peacetime Economy

Survey shows that the nation is already benefitting greatly in new goods, techniques and industries

Finding that little or no research material on the subject was available, Missiles & Rockets last spring sent questionnaires to several hundred companies in the missile and space fields, asking which of their products developed during defense or space research had resulted in products or techniques for peacetime usage. The survey resulted in the story which follows. We realize that the survey is far from complete and would welcome further information; the field—now and potentially—is almost limitless.—Editor.

by Edward J. Michelson*

WASHINGTON—Vast U.S. government spending during the past Cold War decade for missile and space research, technological military development, testing and space exploration activities is beginning to yield tremendous dividends in terms of American economic growth.

The nation has spent billions for research and development in these fields. The current R&D budgets alone for the Department of Defense and the National Aeronautics and Space Administration total more than $4.2 billion. Of this more than $2.4 billion is for missiles and space activities.

From this Cold War research, quantities of new consumer goods, services and industrial processes are now appearing on the American scene. Even new industries have appeared as the results of inventions, techniques and knowledge gained since the dawn of the Space Age.

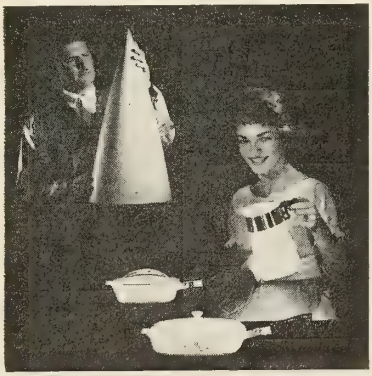
One of these is the computer industry. Computers were developed as a result of military demands for faster figuring and the industry itself has developed as a result of the even greater demands imposed by missile and space operations.

Companies of virtually every size and description participating in missile and space programs today are alert to the opportunities for new industrial, commercial and consumer ventures growing out of their work.

The firms surveyed by M/R range in size from **General Motors** to small electronics companies founded in the first half of the now-ending 1950's. In numerous cases, newcomers in nucleonics, avionics, metallurgy, "hardware" production and plastics are planning to promote goods and services for industrial and consumer use even though the enterprises don't have sales promotion or marketing staffs. Their sole customer until now has been Uncle Sam.

One Space Age supplier, **North American Aviation, Inc.,** has gone to the length of establishing a subsidiary, **Navan Products, Inc.,** for the specific purpose of marketing its own and others' inventions.

Evidence that military-supported scientific and technological advances have already resulted in new goods now under development abounds. **Westinghouse Electric Corp.** is actually showing three prototype appliances in television commercials—thermoelectric devices for cooling and heating. Thermoelectric research has been a company interest sporadically since 1937, but it was Navy and Air Force requirements for highly efficient, lightweight prime energy sources for space vehicles that spurred this development.



MATERIAL developed for radomes was made into a tough line of kitchenware by Corning Glass Works.

Corning Glass Works cites an impressive array of products ranging from Pyroceram skillets and pans to silicone rubber interlayer material, making possible "windows" capable of resisting Mach 2 temperatures (approaching 500°F). Emphasis is on improved glass-making technology and higher quality materials for myriad uses including nuclear food preservation and power reactors.

• **Born of WW II**—Corning developed a mass-production process for the manufacture of optical glass to meet military needs during World War II. The company's scientists developed platinum-clad melting chambers and blending machines that made possible an unprecedented production rate of 50 pounds of optical glass per hour.

In the ensuing years, the process was adapted to production of optical blanks of all sizes—for use in lenses for bombsights, periscopes, aerial cameras, wind tunnel windows and missile-tracking optics. (See cover picture.)

The production technique allowed Corning to go into peacetime production of low-priced, high-quality lenses for spectacles, telescopes and cameras.

The chief accent of management men responding to a survey questionnaire is on development of better, more durable materials, more reliable manufacturing techniques and increased product reliability. This reaction is inevitable; American businessmen have traditionally excelled in developing engineering ideas aimed at offering end products of higher quality, greater utility and minimum unit manufacturing cost.

In the missile and space field, gains

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have been made in such areas as materials, electronics, equipments, medicine, propulsion, communications, aeronautics, air traffic control and navigation, and knowledge of human psychology and physiology.

• **Competitors reluctant**—For obvious competitive reasons, some firms are none too communicative. This is especially true of the motor car manufacturers. **Chrysler Corp.** acknowledges that its propulsion work for satellite vehicles is bound to generate scientific and engineering suggestions to be considered ultimately for application to its

'SWORDS INTO PLOWSHARES'—SOME EXAMPLES

COMPANY	MILITARY USE	CIVILIAN USE
Stalker Corp., Essexville, Mich.	Jet Engines (for GE)	Jet engines
Rahm Instruments, Westbury, N. Y.	Pressure transducer for Vanguard	Commercial pressure measurement systems
RCA, Los Angeles	AF and Navy weather radar, including Loran; Navy beacons	Commercial Airlines
	Ground weather radar for AF	Weather Bureau, radio-TV stations
	Micro-miniature Army transmitters and receivers	Police and Doctors
McCormick Selph Assoc., Hollister, Calif.	Explosives	Several products applicable, but no action so far in exploiting commercial market.
Summers Gyroscope, Co., Santa Monica, Calif.	Target Drone Autopilot	Inexpensive pilot assist and safety device for private aircraft.
Allegany Instrument Co., Cumberland, Md.	Electronic integrators and amplifiers; equipment for measuring low-level electrical signals from thermocouples, load cells, and pressure cells used to evaluate performance of solid fuel rockets at static test facilities.	Medical research to measure body temperature and blood flow.
Stavid Engineering, Inc., Plainfield, N. J.	AN/FMS-3 designed to receive, locate and plot lightning flashes, over a 2,000-mile radius. Six satellite receivers take in and simultaneously transmit data by telephone wires to central receiving and plotting station where lightning flashes are plotted on a cathode ray tube. Overlays are marked by a monitor to show movement and location of fronts.	For Weather Bureaus. The system is being installed in the Tornado Belt to detect severe atmospheric disturbances.
General Precision Laboratory, Inc., Pleasantville, N.Y.	Radan (radar doppler automatic navigator) for military aircraft	Radan 500 for business and commercial aircraft
ECO Engineering Co., Newark, N.J.	Inert thread sealing compound, developed for Redstone Arsenal.	T-Film thread sealing and anti-seize compounds for pump manufacturers serving process industries.
Miskella Infra-Red Co., Cleveland, Ohio	Atlas Satellite	New Infrared appliances, i.e., lamps, hot dog roasters, switches, ovens.
Fairfield Engineering Co., Marion, Ohio	Automatic control components	Proximity switches, plugs, valves, cylinders, and other components already are an integral part of industrial conveyor systems.
Filtors, Inc., Port Washington, N.Y.	High environmental reliability	Improved commercial airliner equipment, for high reliability of operations.
AVCO Lycoming Div., Stratford, Conn.	T-53 and T-55 Gas Turbines for Army and Air Force	Engines for helicopter field. Marine and industrial versions.
Frank R. Cook Co., Denver	Silver-zinc batteries developed for guided missile power	Ideal for portable and airborne applications requiring small size and light weight.
Rosemont Engineering Co., Minneapolis	Variety of precision platinum resistance temperature sensors developed for missiles	Any industrial or commercial applications in which higher accuracy and stability is needed for temperature measurements.
B&F Instruments, Inc., Philadelphia	Accelerometers for aircraft and missile flight tests; torquemeters to test missile components; strain gauge control equipment for aircraft and missile structural testing.	Univ. of California auto crash tests use these accelerometers; other instruments are in use in motor testing, shipbuilding and bridge construction.
Fairchild Engine and Airplane Corp., Hagerstown, Md.	Armalite C-82 Radar	Armalite principle in civilian guns. Cargo carrier in South America. Proximity warning device for aircraft.
Miles Reproducer, Inc., New York, N.Y.	Recording equipment	Automatic voice recorded started and stopped by sound of voice; "Walkie-Recordall"—miniature conference recorder-transcriber.
Edgerton, Germeshausen and Grier, Boston	Milli-mike traveling wave oscilloscope for Atomic Energy Commission.	Now available for laboratory purposes, to measure high-speed electrical phenomena occurring in less than one millimicrosecond.
Southwestern Industrial Electronics, Houston	Miniatured electronics and bearings (a Division of Dresser Industries)	For portable radio and TV; microminiature roller, needle, and ball bearings for such equipment as compressed air-turbine dental drills.
Marblette Corp.	Epoxy Resin #617—missile application Epoxy Resin #341 in atomic submarine construction	For plastic tooling, metal bonding adhesive plus casting and laminating applications; #341's primary distinction is protection against radiation.
B. F. Goodrich Aviation Products, Akron, O.	New fabric-laminated tire treads	
Nacimac Products San Diego, Calif.	Film resistance thermometers	For animal and human temperature measurements.
AMP, Inc., Harrisburg, Pa.	Solderless wiring connectors	
Don-Lan Electronics, Inc. Santa Monica, Calif.	Coaxial switches, waveguide switches, antennas	Most microwave components
General R. F. Fitting, Inc., Boston	R F coaxial connections	
G. B. Electronics, Inc., Valley Stream, L.I., N.Y.	Tracking antenna systems, SVE arrays, infrared devices	Scatter communications systems for networks; infrared detection systems for aircraft and other testing.
Corning Glass Works, Corning, N.Y.	Silicones for electric motor insulation, subzero lubricants, water-repellent and weather-	Better glassmaking technology for myriad products.

commercial product lines.

General Electric also is reluctant to speak in general terms of the potentialities of its space work assignments for other manufacturing divisions. GE regards space travel as an extension of terrestrial travel. GE also points to benefits in the development of materials—metallic and otherwise—which make possible recoverable nose cones capable of withstanding the stresses and strains of re-entry.

• **Sizing up markets**—Volume procurement of lithium has brought down the price, sparking producers' thinking

COMPANY	MILITARY USE	CIVILIAN USE
Corning Glass Works, Corning, N.Y. (Cont.)	resisting coatings; resilient rubberlike plastic	
	Fused silica in radar delay lines	Wind tunnel windows, crucibles and laboratory instruments.
	Optical blanks for aerial camera lenses and wind tunnel windows	Radiation shielding windows
	Ribbon glass for capacitors	For electronics capacitors now in use.
	Radar bulbs	Air traffic control equipment.
	Dosimeter lockets	For nuclear food preservation.
	Ceramic reactor fuels	Power reactors.
	Pyroceram—in missile radomes	For skillets, pans and other utensils.
Nortronics, Inc., Hawthorne, Calif.	Voice interruption priority system	Process control warnings; verbal assembly line production control
William Brand & Co., Willimantic, Conn.	Turbo Ribbon cable for missiles	For communications systems and electronic components generally
Fairchild Camera and Instrument Corp., Syosett, N.Y.	Airborne radio compass Automatic gun cameras	Commercial aircraft Surveillance cameras in banks, toll booths, etc.
	T-11 Cartographic Aerial Mapping Camera	Commercial mapping firms
	35mm and 16mm mini-rapid film processor	For television newsfilms and commercials, industrial films
SKF Industries, Philadelphia	Quiet running bearings for underwater craft	For electric motors; all precision, special tolerance and unique design bearings originally made for military are now in industrial use.
Douglas Aircraft, Santa Monica, Calif.	Data reduction techniques, camera equipment and films, miniaturization of electronic components.	
Essex Mfg. Co., St. Louis	Cryogenic disconnects, pressure switches, check valves, pyrotechnic components;	All are in industrial use
	Liquid nitrogen missile disconnects; liquid propane refrigerant disconnects.	
Aeroquip Corp., Jackson, Mich.	Hoses of Teflon for jet aircraft, missiles and launchers.	Extensive industrial steam-carrying and chemical uses.
Chemalloy Electronics Corp., Santee, Calif.	Fluxless aluminum soldering	For kitchen utensiles repair, gutters, flashings, TV antennas, electrical joints, auto repairs, fencing, milk cans, silos.
American Brake Shoe Co., New York, N.Y.	Machinable manganese steel for use as fittings in mine-sweepers	For structural components for electric power equipment and heavy electronic gear.
	Ultra-high strength steel castings for missiles and air-frames	For lightweight, complex shapes in structural components requiring High dimensional accuracy, exceptional strength and complete reliability.
American Brake Shoe Co., New York, N.Y. (Cont.)	Lightweight hydraulic pumps for missiles and aircraft	Industrial hydraulics, automated machinery, electro-hydraulic and hydraulic-pneumatic control systems.
Cannon Electric Co., Los Angeles	Solenoid-actuated lock mechanism on Atlas, Thor (as umbilical disconnect)	In wing flap brake mechanism of Lockheed Electra
Sanders Associates, Inc., Nashua, N.H.	Flexible printed circuitry	
DeHavilland Aircraft of Canada, Downsview, Ontario	Transistor inverter electrical power supply	Instrument inverters, power inverters, de-icers for windshields.
	Infrared devices	Cell coolers, detecting devices, tracking devices.
	Turbo-alternator electrical power supplies	Standby units for emergency air and ground electrical power
Hart Mfg. Co., Hartford, Conn.	Sensitive relays and small switches for high shock and temperature applications	Computors and sensitive industrial instruments and controls.
Rocketdyne Div., North American Aviation, Canoga Park, Calif.	Hydrazine liquid storable propellant	Drugs based on hydrazine derivatives for mental illness, tuberculosis
Propellex Chemical Div., Chromaloy Corp., Edwardsville, Ill.	Landing gear actuator for aircraft cartridge-actuated emergency truck brake Technique of explosive or blast forming of difficult-to-mold metals into intricate shapes.	
Westinghouse Electric, East Pittsburgh, Pa.	Thermoelectric power generators	Thermoelectric appliances
General Electric Co., Philadelphia	Improved materials, propulsion for space travel	
Curtiss-Wright Corp., Woodridge, N.J.	Control concepts and other research for advanced air vehicles	Various applications in industry
Raytheon Mfg. Co., Boston	Microwave systems, radar equipments	Market planning for industrial and commercial sales.
Chrysler Corp., Detroit, Mich.	Propulsion for space vehicles	Possible application in automotive industry.
Navan Products, Inc., Los Angeles	Subsidiary of North American Aviation, newly established for marketing parent company's (aircraft, missile, nuclear, rocket engine and electronic designs) and other inventions commercially.	Specializing in marketing, financing, and manufacturing of inventions, with emphasis on national sales.
Food Machinery & Chemical Corp., San Jose, Calif.	Techniques for m/r space and allied fields by company's ordnance division.	New technique for continuous welding process on aluminum.
Convair Div., General Dynamics, Pomona, Calif.	Hyge machines for shock test facilities of Lockheed, Martin, Avco, Minneapolis-Honeywell, Sandia Corp., and other firms.	Actuator for shock-testing, simulates shock for precision test needs of large and small industries.

some unlikely diversifications . . .

about commercial markets. The sole commercial use that immediately comes to mind is in nickel-oxide storage batteries. **Firestone** and **Shell Chemical** are reported to be employing a lithium catalyst in synthetic rubber production. **Frank R. Cook Co.,** Denver, suppliers of silver-zinc batteries for guided missile power, look to civilian customers in need of lightweight and small (one-sixth to one-fourth the dimensions of conventional batteries) for portable and airborne applications.

Rosemont Engineering Co., Minneapolis, has only begun exploiting the market for a variety of precision platinum resistance temperature sensors developed for missiles. The company stresses the high accuracy and stability of its product for temperature measurements, in selling for all industrial or commercial applications.

• **Cases in point—Raytheon Manufacturing Co.** uses the term "fallout" for products originally designed for military needs. In World War II, Raytheon supplied three of four Allied warships with surface search radars. Today Raytheon claims to be the largest single producer of such equipment for the world's merchant shipping and passenger liners.

In little more than three years, Raytheon's payroll has increased from 18,000 to 39,000. Where its ratio of government to non-governmental activity was 60-40% in 1956, company responsibilities for the *Falcon* and *Sparrow III*, among other systems, have increased the ratio to 85-15%.

With an eye to the future, Raytheon's market planners are concentrating on resources which, combined with capabilities of companies Raytheon has been acquiring, will make the company name as familiar in commercial marts as it was before its radio-TV operations were sold to **Admiral Corp.**

A major rubber company, whose identity is withheld by request, reports that a high-speed, fabric-laminated tread tire used on recoverable test missiles is also being sold now for commercial jet aircraft. **Marblette Corp.,** producer of resins for missile and rocket applications and atomic submarine construction, cites civilian uses for each type. One is already popular in plastic tooling, metal-bonding, adhesive and casting, and laminating operations; the other, in high-density casting compounds. The latter type resin is lead-filled for barriers against radiation.

SKF Industries is now producing for non-Government users all precision, special tolerance bearings for electric motors, including those of unique design, that the military had to have. Both Air Force and Navy needs have contributed greatly to such advances. A major Air Force contribution in recent years was the technique for plating nickel and tin-indium without electrical current to prolong the life of friction bearings and similar parts.

• **Peace-to-war-to-peace**—The interrelationship of peaceful industrial research and that for defense is graphically illustrated in the case of Westinghouse Electric's interest in thermoelectrical developments.

The company began to study the possibility of converting electricity directly to heat in 1937. By 1939, the Westinghouse Exhibit at the New York World's Fair was showing thermocouples demonstrating this principle.

Early in the 1950's, management's imagination was fired by the possibility of thermoelectric household appliances which would be highly efficient, have no turning parts, nothing to wear out. The intensive laboratory activity for the next three years centered on a small but highly dependable prime source of electricity, a generator that would be gas-fueled at first but eventually nuclear-fueled.

The Navy happened to be in the market for such a power generator. Since Westinghouse had acquired considerable experience and knowledge in this field, the company was put to work. The objective: to build a lightweight, highly efficient generator capable of performing the selective cooling required for electronic gear in aircraft and in equipments such as those used in the Arctic for communications networks.

The advent of the Space Age heightened the need for power generators for satellite vehicles. Westinghouse is subcontractor in this connection for projects on which **The Martin Co.** and **Minnesota Mining and Manufacturing** have prime responsibility. Westinghouse also has an Air Force order for a TAP-100 (Terrestrial Auxiliary Power —100 watts) generator for remote locations such as the Arctic. Ultimately, such equipment, relying on nuclear fuel, can power relay stations for round-the-world communications.

A Navy contract calls for a 500-watt generator and a thermoelectric air conditioner for shipboard use, with a capacity of one ton. This unit is a parallel development of the baby bottle warmer-cooler, dehumidifier, and refrigerator prototypes already being pictured in ad copy as part of Westinghouse's projected line of thermoelectric home appliances.

• **Improbable diversification**—Most Americans are not only startled by the fact that billions in Government scientific and engineering research and technological development pay off in terms of new jobs, new products, new industries and the resulting increase in economic wealth; they are also surprised to see that companies engaged in one line of manufacturing diversify into remote fields as a result of their defense activities.

The public thinks of **Food Machinery and Chemical Corp.** as a packaging business, with some ordnance work. Not generally realized is the new technique Food Machinery has for continuous welding of various types of aluminum, including those of considerable thickness.

Another example is the case of **Rocketdyne Division** of **North American Aviation,** a division created because of the Space Age. Rocketdyne produces hydrazine liquid storable propellants. Rocketdyne officials say drugs based on hydrazine derivatives have been tested in terms of treatment for mental illnesses and tuberculosis. The company gives no indication that it contemplates entering the pharmaceutical industry. But it is significant that most of the 10,000 compounds that have been introduced in medical practice since 1939—the outbreak of World War II—were available much sooner than might otherwise be the case because of mobilization requirements and wartime demands.

General Bronze Corp., a leading manufacturer of metal windows and other construction items, is preparing to spill over into the industrial and commercial electronics fields. A subsidiary devoted to space science and engineering requirements, **G.B. Electronics, Inc.,** was established less than two years ago, to develop tracking antenna systems for missile support equipment supplied by prime contractors. The company has now gone in for infrared research, with prospects of turning out highly sensitive devices for such industrial uses as the detection of flaws in the welding of aircraft.

• **Moving into aeronautics**—The aeronautics industry is eyed by numerous companies—even though some of the best-known aircraft manufacturers, such as **Douglas** and **Northrop,** are turning to such fields as data processing and reduction techniques, and systems for production control in highly automated plants, respectively.

Summers Gyroscope's inexpensive autopilot for target drones has applicability in light aircraft as a cheap pilot assist/safety device. **Avco's** Lycoming Division anticipates that within a year it will be selling commercial versions of its T-53 and T-55 gas turbines for helicopters. Marine and industrial versions also will be offered. **General Precision Laboratory,** prime contractor for the Federal Aviation Agency's semiautomatic traffic control system, cites its radar doppler automatic navigator (RADAN 500), for sale to business and commercial aircraft. **The Stalker Corp.,** Essexville, Mich., mentions jet engines it builds for the military under GE subcontract as a line for other buyers.

RCA is optimistic as to the civilian usefulness of its radar equipment for Air Force and Navy weather studies. **Stavid Engineering, Inc.,** Plainfield, N.J., has elaborate apparatus for locating lightning flashes over a 2000-mile radius and for instantaneous transmission, monitoring and plotting of weather front locations and movements.

• **Peaceful electronics**—A vast array of precision instruments, refinements and improvements on automatic production control components, photographic equipment, and infrared appliances will go into industrial and consumer marts. **Miskella Infra-Red Co.,** Cleveland, is transferring capabilities and know-how that go into its tasks for the *Atlas* satellite to new types of electronic lamps, hot dog roasters, switches and ovens. **ECO Engineering Co.,** a Newark, N.J., supplier of Redstone Arsenal, had to develop an inert thread sealing compound for that key customer. Now ECO counts on such sealing and anti-seize compounds to appeal to pump manufacturers in the process industries.

The tremendous impetus which defense research gave to the miniaturization of electronic components continues. Dresser Industries' **Southwestern Industrial Electronic Co.,** Houston, is "transistorizing and minifying" for portable radio and television sets. In addition, Southwestern makes micro-miniature roller, needle and ball bearings for compressed air-turbine dental drills. Another missile electronics supplier, **Miles Reproducer, Inc.,** New York City, is promoting an automatic voice recorder which starts and stops at the sound of a voice, and a "Walkie-Recordall" which is a miniature conference recorder-transcriber.

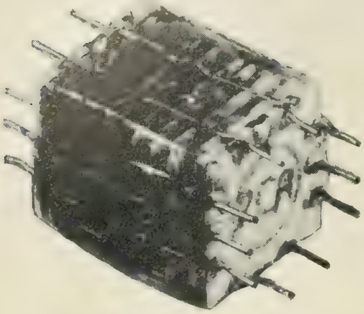
• **Long-range jobs**—An eloquent indication of the benefits to industry of current programs is the spate of large Engineers Wanted ads in metropolitan Sunday newspapers; most of the advertisers are Space Age research and development organizations.

In the hectic competition for the most desirable mechanical and electronic engineers, companies emphasize the long-range attractions of careers in their laboratories. The Propeller Division of **Curtiss-Wright Corp.,** for example, specifically mentions that the design, development and testing work available on "advanced air vehicles" and the control concepts under development have "application in industry as well as many other areas yet to be fully explored."

A few winters back, after the Soviets had orbited their second satellite, a group of U.S. Congressmen landed in Sydney, Australia, on a transpolar Antarctic flight. One of them, Rep. Torbert H. Macdonald of Boston, was properly respectful in reading of the accomplishment in a Down Under newspaper. The hotel elevator operator was reassuring and consoling. "You Yanks needn't worry," he said. "You'll do all right. And when you get your satellites going round the earth, they'll be much better. They'll be air-conditioned!"

The lawmaker from an area abounding in electronics production and research activities for the Space Agency and ARPA thinks this point was well taken. Experience has proven that every military undertaking in nuclear fission and fusion, astronautics, electronic computation and new aerodynamic and hydrodynamic R&D is from the outset destined to pay off in new skills, technologies, industries and related forms of economic wealth.

LEFT: Premier Khrushchev on his visit here may follow the same path as his deputy, Frol Koslov, shown here visiting Westinghouse's peaceful atomic power plant at Shippingport, Pa. With Koslov at the main control console is Vice Admiral H. G. Rickover, father of the atomic sub. RIGHT: This the world's first industrial atom smasher at Shippingport, a direct industrial outgrowth of the atom bomb.



Microminiaturization—A Revolution Under Way

M/R reports on a fast-developing concept that will save millions and boost reliability

by Charles D. LaFond
and James Baar

WASHINGTON—Yellowish smoke rolls across the meadow and shrouds the *Lacrosse* fire direction truck.

Inside the truck the red fire button on the console flashes. The sergeant moves his hand to push it. Then he stops. The light has gone out. In its place, a trouble indicator light is flashing: A bank of binary flip-flops in the guidance computer has failed.

A private quickly removes the micro-modular bank, throws it away and inserts another. The fire button flashes again. The sergeant pushes it. Only seconds have been lost . . .

This is the micro-module concept in action.

Microminiaturization—The manufacture of highly reliable and highly standardized electronic equipment one-tenth the size of existing miniaturized equipment—is a billion-dollar technical revolution that already is beginning to sweep the electronics industry.

It is not something that is coming in the next 10 or 20 years. It will be here in full force about two years from now.

It means:

- Swift, simple "throw-away" maintenance of military electronic equipment both in combat and behind the lines.
- Saving of millions of dollars a year in military maintenance costs.
- The cramming of a maximum of 600,000 components per cubic foot into a missile, space vehicle or computer, instead of the present maximum of 50,000 or 60,000.
- Improvement of reliability by up to 50%.

The effect of this on the development of missiles and space vehicles as well as all other military and commercial equipment employing electronic components is obviously going to be tremendous.

Moreover, the effect on the multibillion-dollar electronics industry will obviously be equally great. Nearly 100 firms have taken part in the R&D program. Nearly all others have watched it closely.

The dramatic story of how this revolution has come about starts only about 18 months ago in the laboratories of the U.S. Army Signal R&D lab at Ft. Monmouth and **Radio Corporation of America** at Camden, N.J.

The Signal Corps and RCA set out to radically improve the present level of miniaturization using only proven components available today.

They wanted components that are smaller, cheaper, standardized and easier to maintain. At the same time, they wanted a design so flexible that radically new components now under development could be absorbed into the system in the future.

The result was the micro-module concept.

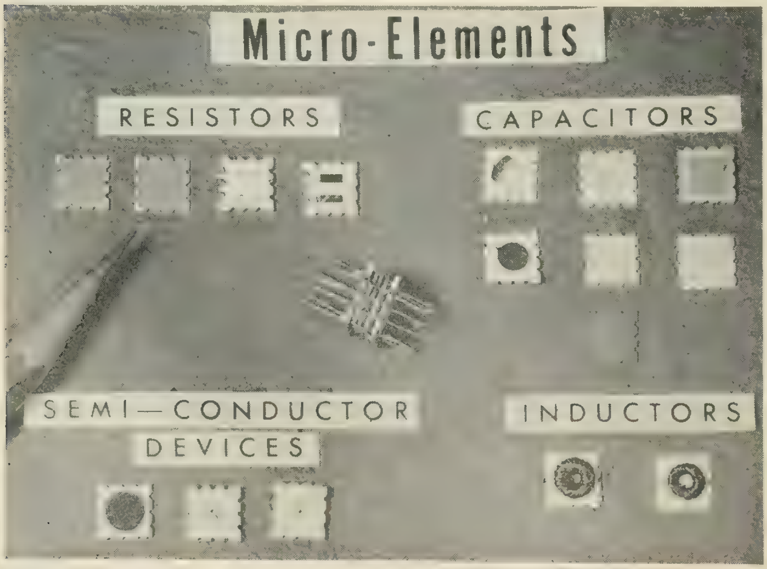
- **Program grows**—RCA began the initial design program April 1, 1958, after receiving a two-year, $5-million contract from the Signal Corps. The contract recently was increased by $2.4 million and extended another year.

The total program probably will run to about $15 million in Federal money—a bargain basement figure made possible by sizeable industry contributions.

However, a fourth year and more funds may be added to the program depending on how quickly industry assimilates the program's results.

The first year was directed to the development of the basic module-element configuration and the prototype production of various components. This year more prototype elements are being developed.

Approximately half of the total number of different micro-elements to be built are already available and are undergoing comprehensive performance tests and evaluations. In all, the program calls for nearly 5 x 10^6 unit hours of life testing.



But if you want to try, do this:

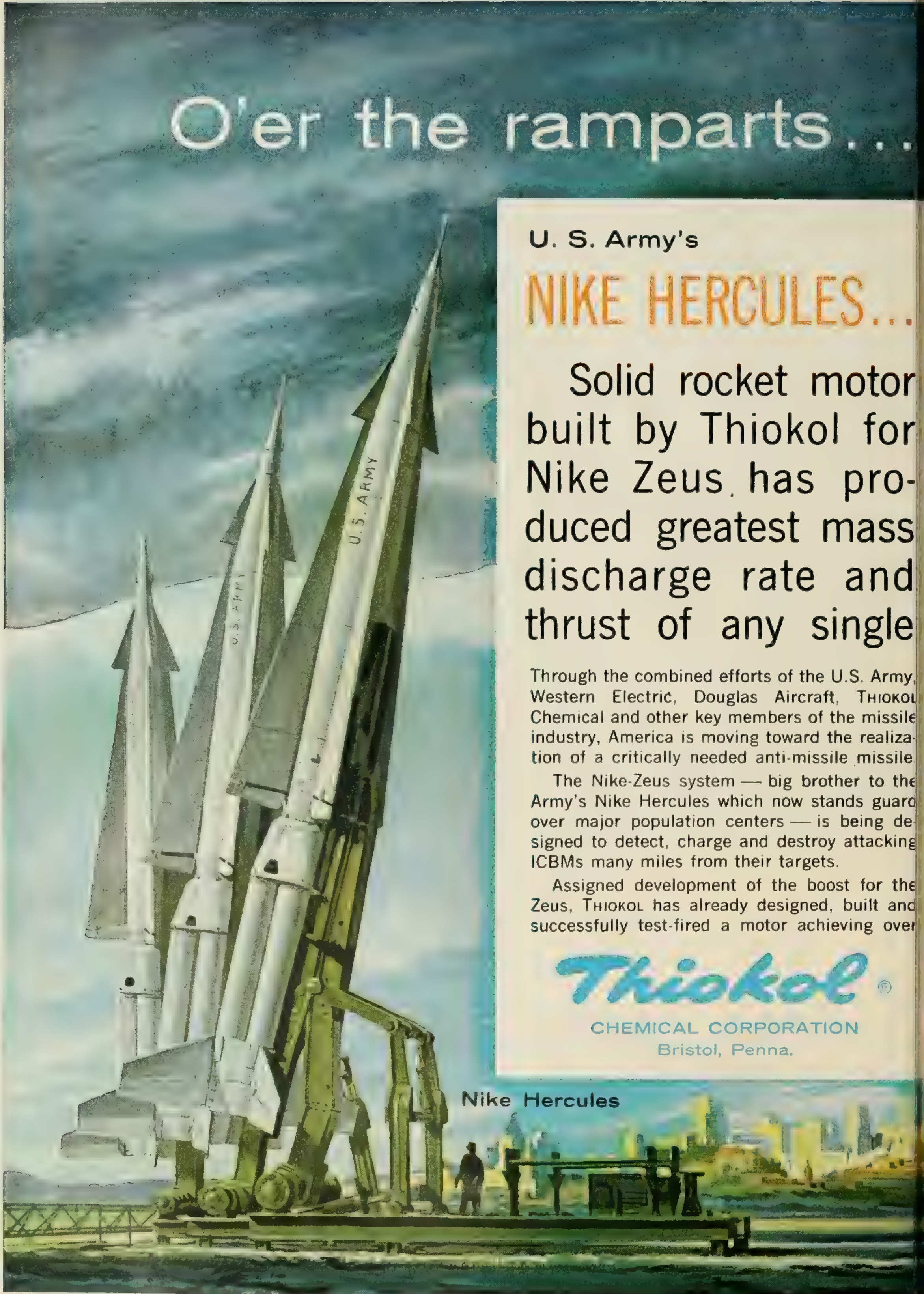
- Spend 20 years applying advanced metallurgy to production.
- Shake down 35 high-temperature alloys in the laboratory.
- Fabricate these super-alloys into critical hot-part components for prototype power plants.
- Swing into volume production of proved designs.
- Prove, over and over again, that you know what you're doing—with jet, propjet and piston engine components and afterburners, ramjets and rocket motors.
- Make your name a byword for high-temperature research and development...for precision-made components and complete power packages.

Better still—take a 20-year stride by putting Ryan to work on your heat problems.

RYAN BUILDS BETTER

AIRCRAFT · POWER PLANTS · ELECTRONICS

Ryan Aeronautical Company, San Diego, Calif.



O'er the ramparts . . .

U. S. Army's

NIKE HERCULES . . .

Solid rocket motor built by Thiokol for Nike Zeus has produced greatest mass discharge rate and thrust of any single

Through the combined efforts of the U.S. Army, Western Electric, Douglas Aircraft, Thiokol Chemical and other key members of the missile industry, America is moving toward the realization of a critically needed anti-missile missile.

The Nike-Zeus system — big brother to the Army's Nike Hercules which now stands guard over major population centers — is being designed to detect, charge and destroy attacking ICBMs many miles from their targets.

Assigned development of the boost for the Zeus, Thiokol has already designed, built and successfully test-fired a motor achieving over

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400,000 pounds of thrust—power enough to deliver the instant reach of high altitudes needed for effective defense.

While the Zeus booster stands as the most powerful solid propellant motor now on record, it in no way represents the ultimate capability of present THIOKOL facilities. Current capacity includes motors still larger—of ICBM and even satellite size.

Under Army direction, and in cooperation with Douglas Aircraft, THIOKOL development in the Nike program has advanced the science of rocket propulsion.

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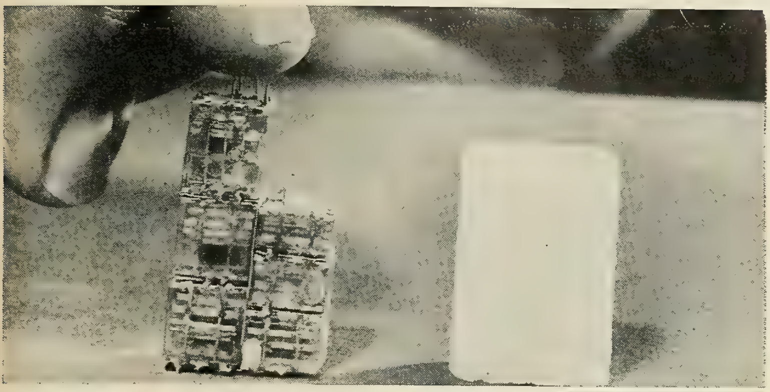
industrial sources are established . . .



COMPRESSED into size no larger than a sugar lump, this military radio illustrates the progress achieved in the Army micro-module program. Receiver is made of micro-modules, circuit building blocks 1/3″ square promising reduction of at least 10:1.

Beginning this year and through the third year of the developmental program, somewhat more than $3 million also will be required for construction of two equipments employing micromodules. Finally, in the third year, a mechanization phase will be entered during which approximately $5 million will be needed to develop pilot production. This includes necessary equipment for automation and the overall evaluation of the completed modules and the two equipments.

• **The concept**—Essentially, the micromodule system is based on the use of very thin wafers connected in a building-block fashion to make miniature cubes of functional circuits.

To lend itself to automatic manufacture, a notched wafer design employing round riser wires was first selected. Internal wafers were specified to be 0.310″ x 0.310″ x 0.010″. End wafers were limited to 0.350″ x 0.350″ x 0.020″. Riser wires were set at 0.013″ diameter and when coated with solder were limited to a maximum overall diameter of 0.014″.

In the assembly of micro-elements to form a micro-module, a 0.01″ space is allowed between each element to provide electrical decoupling. This also provides an allowance for joints and tolerances.

Two types of micro-wafers currently are being evaluated. The original notched design and a notchless design connected by means of flat ribbon conductors.

The micro-elements made from the wafers may be single- or double-sided and other variations provide for adaptability of all the basic components to the micro-element form.

In all, 14 elements have been completed so far. Seventeen types will be made available during the latter half of this year.

After assembling the micro-elements and after completing all of the internal interconnections, modules are then sealed by molding or encapsulating to form a solid body. Encapsulation provides standardization, structural strength, easy handling and environmental protection.

STYCAST 2651 epoxy resin is used as the encapsulant. **Dow Corning** 271 element silicone adhesive resin is used as the inter-face coating. The uniform shape which results from this type of assembly provides a unique standardization.

• **Future assured**—Circuit areas in which microminiaturization capability has been proved include RF, IF, audio and digital. But most important of all, microminiaturization as a concept is an integration vehicle no matter what new components evolve in the future.

Service test models of the first microminiaturized equipments should be completed by April, 1962. One will be a typical tactical radio communication set; the other, a typical tactical computer.

Semi-conductor devices were selected for the active circuit elements in all of the micro-modules. The inherent small size of transistors and other semi-conductor devices lends itself well to the microminiaturization program and a great majority of all electronic circuits employed today are capable of being transistorized.

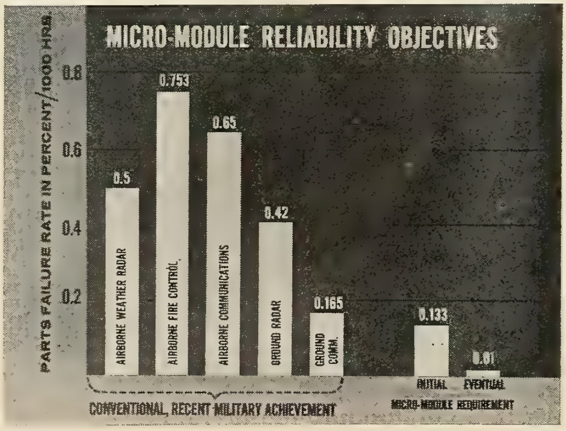
In the future, it is possible that almost all circuits operating at low and at medium power levels will employ transistors and other semi-conductor devices. Of course, the reduced power consumption also makes semi-conductors well suited for micro-module applications.

A great deal of progress has been made in the fabrication of the micro-elements themselves and, in line with this, industrial sources for these elements have been established.

• **Setting sights**—With transistors and semi-conductor diodes certain limits necessarily had to be established. For

ACCEPTANCE TESTING SUMMARY

TEST	SUBASSEMBLIES	MODULES (Total)	ELEMENTS (Total)
LIFE (2000 HRS.)	20	405	6176
SHOCK (50G) VIBRATION (55 CPS) SALT ATMOSPHERE	12	40	457
TEMPERATURE CYCLING MOISTURE RESISTANCE	12	40	457
ALTITUDE (150,000 FT.) VIBRATION (2000 CPS)	12	40	464
SHOCK (15,000 G) SPIN	12	32	442
STORAGE (2000 HRS. MIN.)	--	32	354
TOTAL	68	589	8350



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instance, in the preliminary module design work, four equivalent type transistors were designated. Semi-conductor diodes were limited to three types.

As indicated earlier, the primary consideration in the development of micro-modules has been a vastly improved reliability. The initial goal was to achieve an average part failure rate of 0.1% per thousand hours of operation. Another goal was the establishment of a 50-part complexity level capable of operating in a temperature range of from –55°C to +85°C for more than 15,000 hours. It is believed with the goals established for micro-module reliability an increase of at least 50% will be obtained over the best equipments now in use.

• **Varied benefits**—The future of microminiaturization both militarily and commercially is as broad as the field of electronics.

Army experts feel that wherever size is a factor, micro-modules will be used. Moreover, there are the large economies possible through the cutting of maintenance costs and the possibility of large-scale production.

Space exploration will be one of the first areas to benefit from microminiaturization. Ten times as much electronic equipment will be jammed in satellites of the near future. U.S. astronauts will go into orbit with far more electronic equipment including much larger computers than were previously possible.

The "throw-away" maintenance provided by microminiaturization is precisely what is needed for Missile Age nuclear battlefields.

The rapid massing and dispersal of troops called for by the tactics of nuclear warfare eliminate any possibility of lengthy maintenance work on equipment. The chances of operating large maintenance depots behind the lines are non-existent.

As for other applications, the Army already is reviewing all future equipment designs for possible use of micro-modules. Industry is certain to do the same thing for many commercial items such as radios and TV sets.

Meantime, the Air Force and Navy are kept informed of developments in the micro-module program and can be expected to adapt the results to their uses.

• **Ultimate uses**—The great promise of the microminiaturization concept beyond the immediate future is its expected ability to encompass many of the revolutionary developments seen on the horizon.

Ultimately, active and passive circuit elements probably will lose their identities completely. It is believed that they will be replaced by active volume elements—those emitting an energy flux at a desired frequency—and by passive volume elements—those storing or dissipating such energy.

In the interim period, functional design modules will be categorized by performance, but identity as distinct circuit elements, no matter how complex, will be retained.

As parts densities and functions increase per unit volume, new nomenclature may evolve. It has been suggested that the next step will probably be tagged with the unwieldy "millimicro-miniaturization." Finally, "Angstronics" may be the most descriptive word for more advanced programs.

We are now feeling our way toward an outer understanding of the solid-state era into which we have gained entry. So-called molecular electronics has provided a whole new concept in utilizing semiconductors.

New components employing equivalent or functional circuits are being born daily:

• Silicon Trigistors, by **Solid State Products, Inc.,** has a triggered bistable transistor with characteristics comparable to a flip-flop or bistable multivibrator.

• **Texas Instruments** with its Semiconductor Solid Circuits has developed single-crystal functional circuits providing equivalent components densities of more than 3 x 10^7/cu. ft.

• **Westinghouse,** with its Moletronics, is achieving similar results by controlling crystalline structural arrangements in "growing" solid state ribbons. Many complex circuits have evolved. Currently it is applying Peltier-effect techniques for heat stabilization in more advanced circuits.

• **General Electric's** tunnel diode shows great promise for the future.

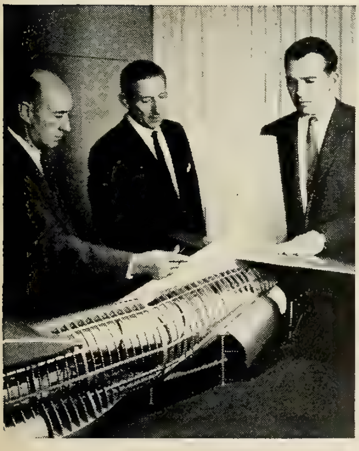
These are but a few of the future "components." In time, all can be utilized in microminiaturized equipments without changing today's concepts of the program.

Micro-Module Program

RCA, prime contractor

COMPONENTS	PRINCIPAL SUBCONTRACTORS
Resistors	Weston Instrument Div., Daystrom Inc.
Capacitors	Sprague Electric Co. P. R. Mallory & Co., Inc.
Transistors	Philco Corp., Lansdale Tube Co. Div.
Semiconductor Diodes	Pacific Semiconductors Inc. General Instrument Corp.
Quartz Crystals	Midland Manufacturing Co.
Substrates	American Lava Co. Coors Porcelain Co.

How to put wings on a warehouse



Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*...saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. Air logistics is only one area of extensive Douglas operations in aircraft, missile and space fields in which outstanding openings exist for qualified scientists and engineers. Some are listed on the facing page.

Schuyler Kleinhans and Charles Glasgow, Chief Engineers of the Santa Monica and Long Beach Divisions, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of **DOUGLAS**

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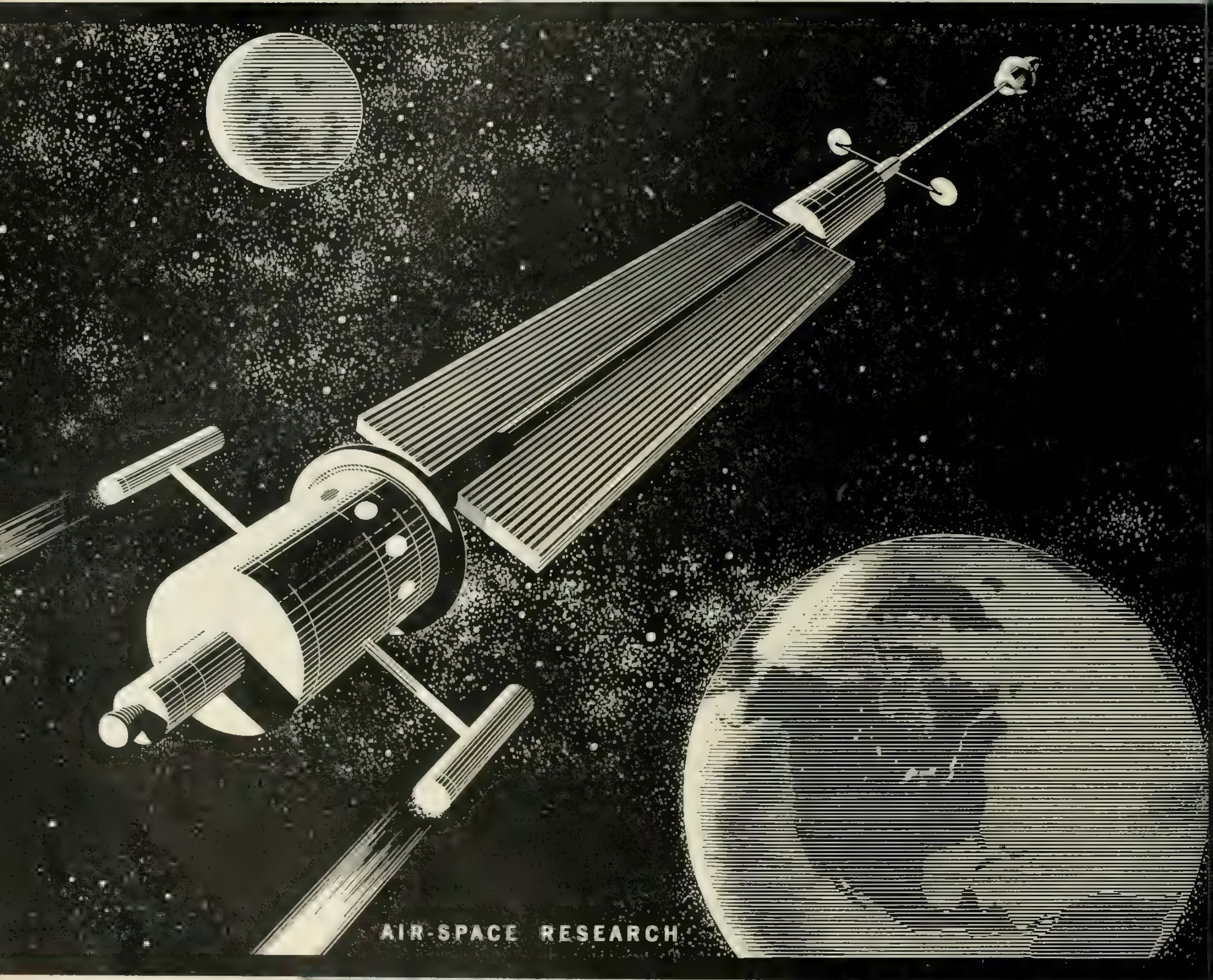
New Concepts for the Space Age Mark 15 Years of Progress by MARQUARDT

When founded in 1944, Marquardt was an organization devoted exclusively to research and development of the ramjet propulsion principle. Today, in its fifteenth year, the Corporation employs more than 5,000 in the creation and exploration of new concepts for the space age. Marquardt is now diversified, operating in five basic areas—all primarily related to the search for earlier and ever more effective solutions to space-age problems.



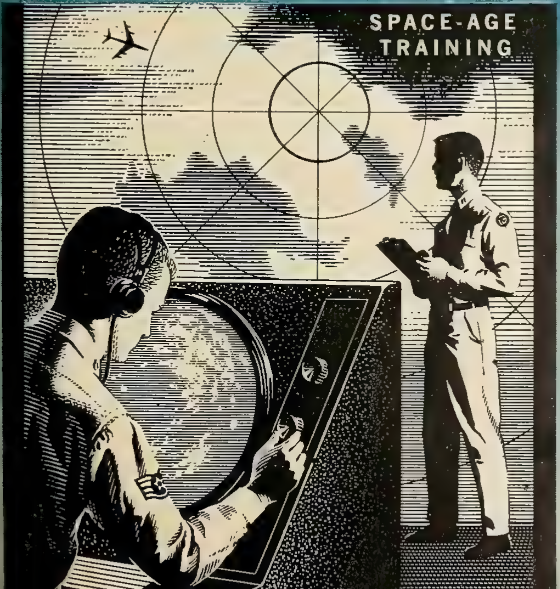
NEW CONCEPTS IN AIR-SPACE RESEARCH spring from ASTRO—Marquardt's Air-Space Travel Research Organization—where studies of an ionic rocket capable of powering future space vehicles are in progress. Other imaginative ASTRO studies span a broad spectrum including high-energy fuels, exotic materials, nuclear powerplants, advanced optics, cryogenics, space medicine, communications and guidance.

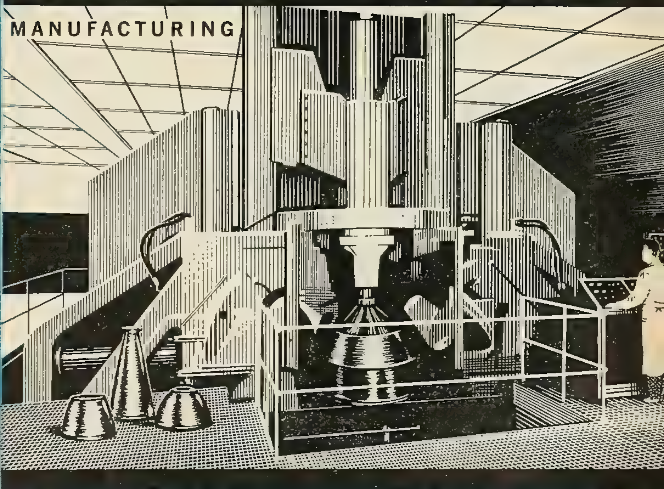
NEW CONCEPTS IN POWER SYSTEMS are in the making at Marquardt's Power Systems Group. Within the Group, Propulsion Division is engaged in continuing studies of a Hyperjet (rocket-ramjet) configuration capable of lifting future satellites from launch pad to upper atmosphere. Controls and Accessories Division is currently developing attitude controls for reconnaissance satellites, while Test Division is capable of ground-testing space-age hardware.

NEW CONCEPTS IN MANUFACTURING are typified by the first-of-its-kind Hufford Spin-Forge at Marquardt's Ogden Division. This 250-ton machine will contribute advances in space-age metal working state-of-the-art, while augmenting the Division's production of supersonic ramjet engines for the Boeing Bomarc IM-99.

NEW CONCEPTS IN SPACE-AGE TRAINING are an important product of Marquardt's Pomona Division—creators of a unique system which realistically simulates a 4,000 mile mission on an 8-foot map. The system will ground-train air and spacemen without risk and at great savings in cost.

NEW CONCEPTS IN RESEARCH ROCKETRY and instrumentation come from Cooper Development Corporation, a Marquardt subsidiary. Cooper has contributed to programs including Explorer and Sunflare projects, and Falling Sphere—is now at work on Project Mercury.





Engineers and scientists capable of making contributions in these and related areas are invited to write The Marquardt Corporation, Corporate Offices, 16555 Saticoy Street, Van Nuys, California; or

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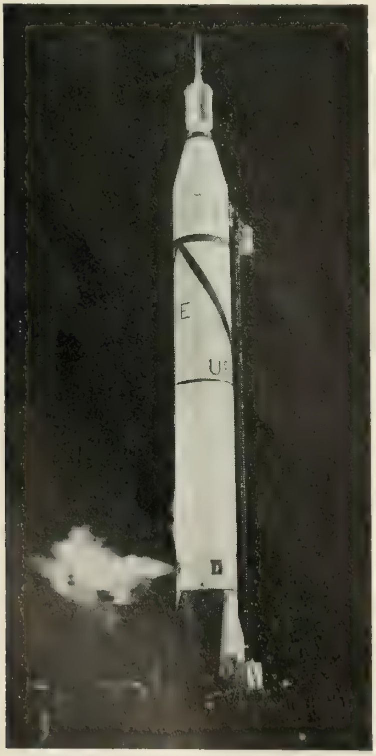
Rocket Reliability Drive Gains Fresh Momentum

Services plan to increase use of off-shelf components; NASA stretches out firing schedules

RELIABLE ROCKETS: Air Force *Thor*, above, lifts off from Cape Canaveral.

Below, modified Army *Redstone* awaits launch of *Explorer I*.



For want of a nail, the shoe is lost;
For want of a shoe, the horse is lost;
For want of a horse, the rider is lost;
For want of a rider, the battle is lost;
For want of the battle, the kingdom is lost—
And all for the want of a horseshoe nail.
—*Old Saw*

by Jay Holmes

WASHINGTON—Last June 23, a three-stage *Vanguard* rocket blasted off from Cape Canaveral. The first stage operated well. But in the second stage a small valve for regulating helium pressure failed to operate on radio command.

The vehicle came apart, and plunged into the Atlantic. For want of a $150 pressure regulator, a $3-million satellite was lost.

Failures in *Vanguard* launchings are merely the most publicized feature of a problem that strikes at every side of our space program: how do we make our rockets more reliable?

There is no reason to believe the problem is confined to this side of the Iron Curtain. The Soviets announce only successes. They haven't announced many recently. It is only logical to reason that there must have been failures.

Simple arithmetic sets out the situation. If a missile has 1000 parts and it must operate for an hour without failure, the probability of failure for each part operating an hour must be less than 1 in 1000. Each part must be good for 1000 hours.

Thousand-hour performance, standard for many aircraft parts and components, is not too difficult to achieve. But as the missile and space vehicle systems grew more complex, the number of parts increased. A navigation system alone can have 10,000 critical components. An advanced vehicle may carry a small computer—whose parts number hundreds of thousands.

- **Cost prohibitive**—Testing for this kind of reliability is out of the question. No one is willing to spend the time and money involved in testing a part for 10,000 hours or more. And even if we do this, what assurance is there that the part will not fail in the first second of use after the test?

The predicament is even more serious when we begin designing vehicles for lengthy voyages in space. J. M. Wuerth, chief reliability adviser to **Autonetics Division, North American Aviation,** points out that if we want to keep failures on a Mars trip below 1 in 1000, each item in a 10,000-part system must be designed to last 7,000,000 years.

Will such reliability ever be achieved? Certainly not in the foreseeable future. Other approaches must be taken if space travel is to be anything but a very dangerous business.

Is there another approach? Some industry spokesmen have suggested reliability might be improved if each part and component is designed specifically for its task in space.

Spokesmen for the military services and the National Aeronautics and Space Administration are cold to this idea.

"Don't design a new part unless you have to," says R. W. Cuthill, reliability engineer for the Army Ordnance Missile Command, Redstone Arsenal, Ala.

"If an off-the-shelf item will do the job, we use it," says an Air Force materiel officer. "However, if there is a reasonable doubt the item will perform, then we must design something new."

"We are now in a state of transition," reports Dr. Homer J. Stewart, director of NASA's office of program planning and evaluation. "Ten years ago, almost no components were taken off the shelf except vacuum tubes and transistors. Now we have experience and can use components in existence or modifications of them."

E. F. Sweetser, director of the Defense Department's Office of Guided Missiles, recalls that there used to be criticism of the military for having too much special designing of parts. The complaint hasn't been heard very much recently, he added.

• **Exchanging data**—The services are moving in a direction opposite from that suggested by industry sources. Army, Navy, and Air Force are establishing a data-exchange system aimed at promoting even greater use of off-the-shelf parts and components in the major missile systems.

Here is how it will work: Each service will code the results of its tests of components on punched cards. Data not subject to coding—such as performance graphs—will be microfilmed and slipped into envelopes in the cards. Cards will be made in triplicate. Central files will be kept for the Army at Huntsville, for the Navy at the Pomona, Calif., Ordnance Laboratory, and for the Air Force at Ballistic Missile Division, Los Angeles.

The files will enable each service to pick the part most suited to any given need. They will cut down on costly, lengthy searches—which sometimes have to be cut short and produce a second-best selection. Civilian contractors and NASA officials with "need to know" will, of course, have access to the data.

Although they'll be an improvement over present practices, these files won't provide the final answer to centralizing reliability information. They will merely report test results in the ballistic missile systems. No information will be included on reliability of parts in use, or on parts tested for other satellite and space vehicle programs.

• **Parts that fail**—Some service organizations have information at lower levels on failures in use. The Army has failed-parts data centrally filed at program levels—such as for *Redstone, Jupiter* and *Pershing*. The next logical step, Cuthill said, would be to set up a central file for all the services on failures in use.

Still another approach to reliability was suggested by a House Appropriations Committee study last spring—write reliability specifications into vendor's contracts. At about the same time, the Air Force directed commands to review weapon systems on contract and determine whether their reliability systems were adequate. Although contracts may not mention reliability, Lt. Gen. C. S. Irvine, then a deputy chief of the Air Staff, declared that contractors nevertheless have an obligation to build adequate reliability into weapon systems.

Navy spokesmen say reliability is implied in their contracts, too. George S. Peratino, reliability engineer in the Bureau of Weapons, says reliability requirements are a part of weapon system specifications, which become a part of the contract even though the requirements are not written into the actual documents.

The Army has tried to establish reliability as a separate effort, Cuthill says. The reliability organization asks contractors to say in advance what tests they will run. Huntsville now is reviewing a three-year *Pershing* test program submitted by **The Martin Co.**

"We try to have reliability people looking over the shoulder of the design engineer," Cuthill said. "Some designers don't like it. They think they know how to do it all themselves. They're right. But we're all human."

• **In-house or out?**—Cuthill's comment points up fundamental differences in the ways the services build missiles. The Army prefers to have in-house experts who can supervise contractors in great detail. Cuthill contends this supervision makes Army weapons more re-

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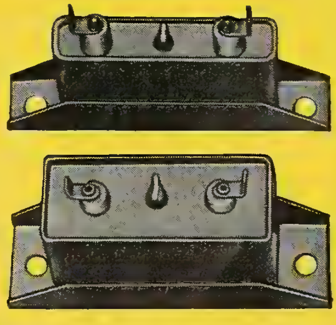

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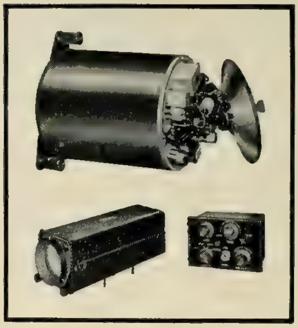

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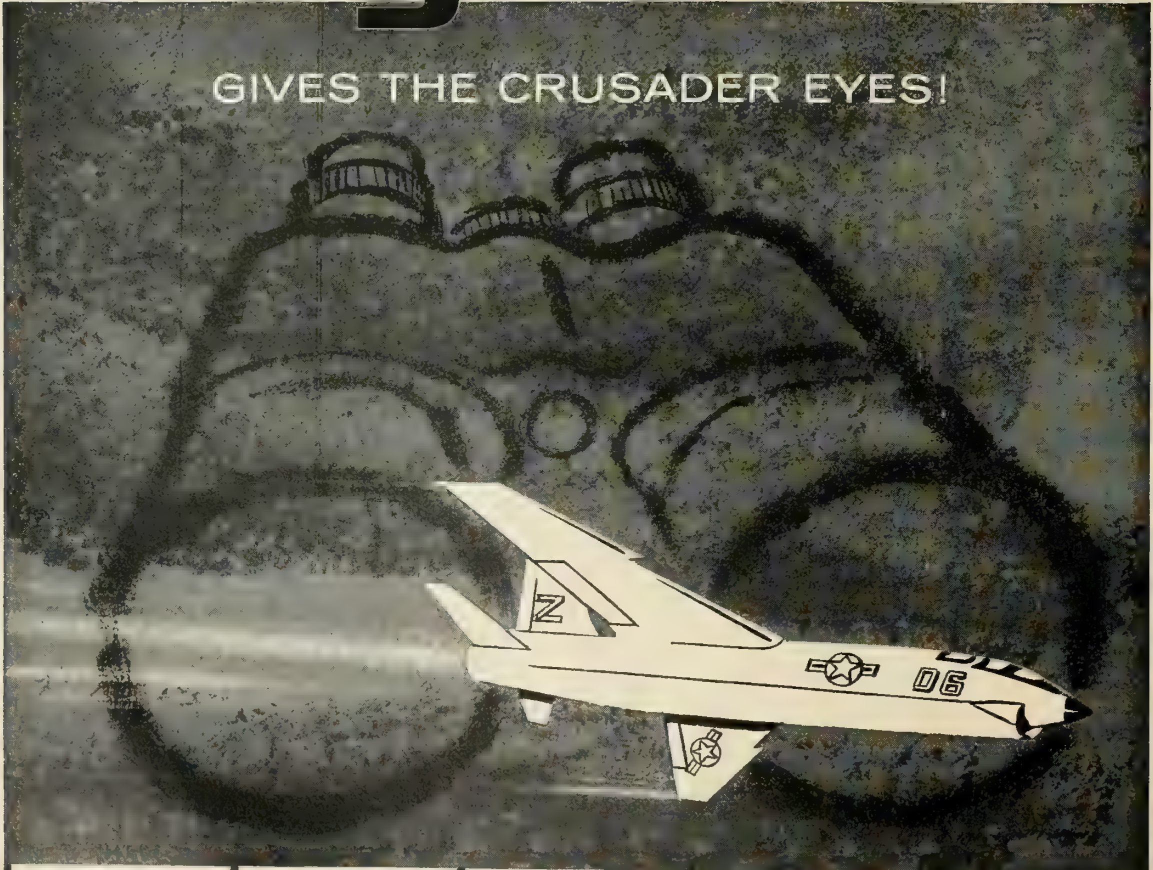

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liable than otherwise.

The Air Force has delegated many of its supervisory functions to **Space Technology Laboratories** and prime system contractors. "You don't have to be a qualified pilot to run an airline, or a bus driver to run a bus system," an AF spokesman said.

The Navy steers a middle course. Some Navy missiles are manufactured at service arsenals; other by civilian contractors.

The Defense Department considers reliability primarily a question of education. "We must impress on ali echelons—the services and industry—the consequences of poor reliability," Sweetser declared. "Like advertising, it's valuable only if you pound the point home."

Both the military and industry are working on schemes to improve reliability. Next winter, the services will sponsor a joint military-industry symposium on reliability. The Army called all its contractors to Huntsville for a day-long briefing last December.

Engineering organizations are busy too. Four leading groups—the Institute of Radio Engineers, the American Society for Quality Control, the Electronic Industries Assn. and the American Institute of Electrical Engineers—will hold a national symposium on reliability and quality control in Washington next January.

- **Corrective action—Douglas Aircraft Co.,** prime Air Force Contractor for the *Thor* IRBM, invited 150 representatives of sub-contractors to its El Segundo, Calif., plant for a seminar on reliability. One announcement: reports on all rejected parts will be made on punched cards. Monthly cumulative reports by part and vendor will provide a basis for corrective action in cases of excessive repetitive rejections.

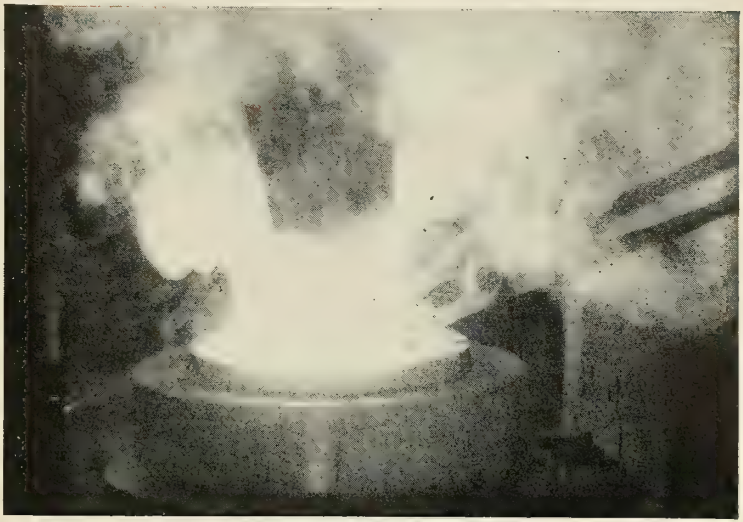
This type of approach—standard industrial quality control—will eliminate the worst offenders. Random inspection of one or two parts in every batch will give an indication of reliability. More thorough testing of larger parts and components will help, too.

"But you can't inspect reliability into an item," says Louis Schlesinger, Navy components engineer. "You can't make an unreliable item reliable. Inspection will prevent the use of defective items, not unreliable."

The stickiest question in developing reliability is the conflict with performance. If we design a rocket case so that 99 of every 100 will withstand a pressure of 1235 pounds per square inch, we may need to use twice as much metal for a case good to 1500 psi. This reduces either the payload or the range of the missile.

(continued on page 34)

LOOK WHAT FANSTEEL'S DOING WITH TUNGSTEN NOW!



Tungsten cup being drawn preliminary to shaping into missile hardware.

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2" I. D. x .060" to .080" wall x 5" deep
2⅝" I. D. x .125" wall x 2⅝ deep
3 5/16" I. D. x .125" wall x 1⅞" deep
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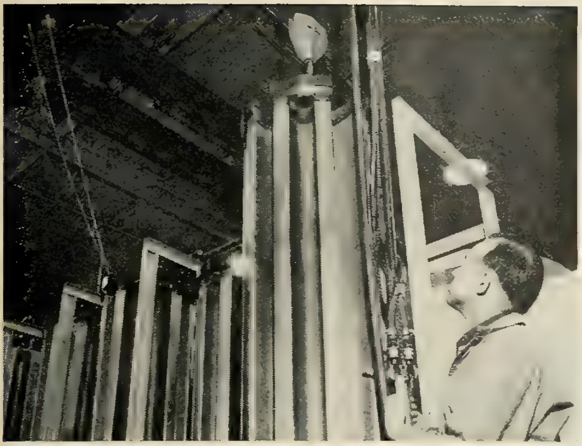
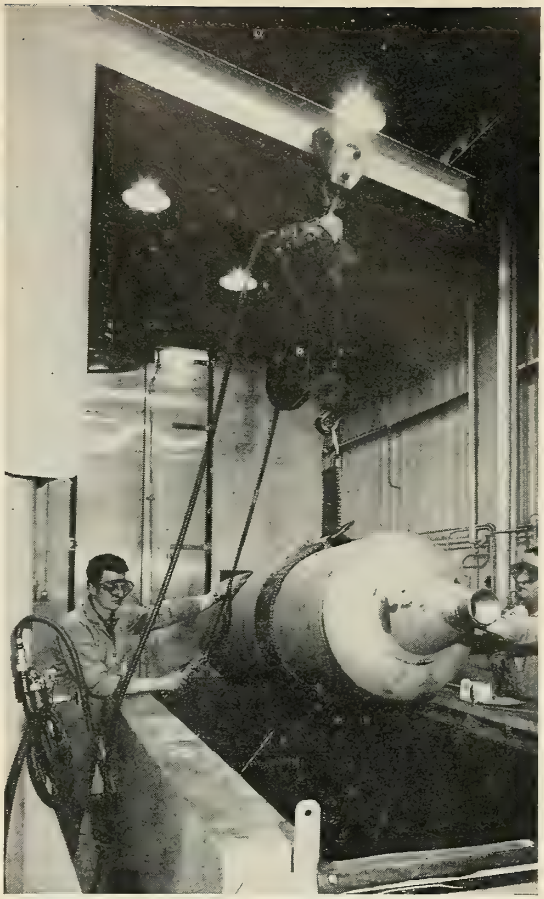
Thiokol Expands in Utah

BRIGHAM CITY, UTAH—Less than two years old, Utah Division of **Thiokol Chemical Corp.** now has 2500 employes working in 85 buildings on a site that spreads over 11,000 square miles.

The solid-propellant plant, valued at $16 million, is owned 60% by Thiokol and 40% by the Air Force. Its features include a mile-long monorail system to facilitate assembly of the largest rocket motors and thrust stands capable of measuring up to 2 million pounds.

RIGHT: Thiokol workers man grinder and gyratory sifting machine, which reduce oxidizer to size before JATO propellant is mixed for *Matador* fuel grain. BELOW: Engine case is checked before it is loaded with cast propellant.



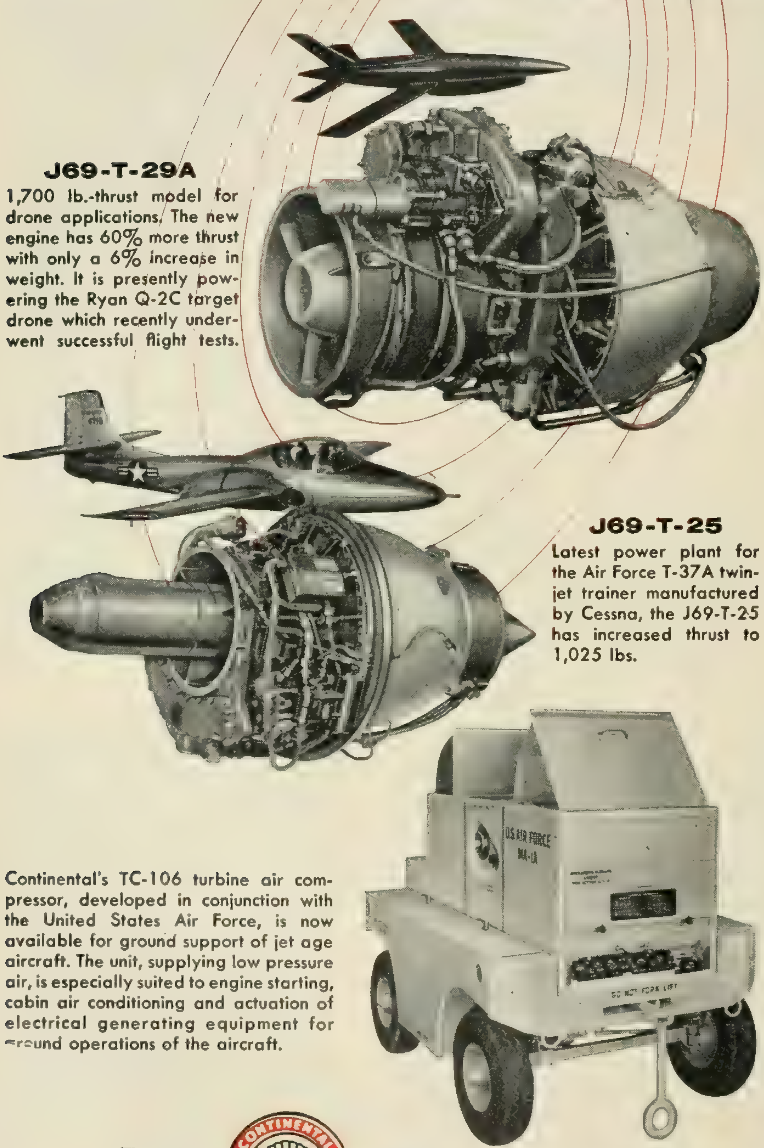


TOP LEFT: Cables hoist metal mandrils used in production of *Matador* booster motor. These are put into the mold until the grain solidifies.

TOP RIGHT: The *Matador* motor case is lowered into a degreaser, which removes rust preventive, lubricants and cutting oils. Now the propellant grain may be slipped into position.

BOTTOM LEFT: Besides the *Matador,* many smaller rockets are produced at Thiokol's Utah Division. Inspectors here check on an 8" case.

BOTTOM RIGHT: *Matador* booster motor moves along a monorail connecting manufacturing and propellant curing building. The motor has been loaded and the propellant has been cured. It will undergo conditioning before going to static area for firing.



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J69-T-29A
1,700 lb.-thrust model for drone applications. The new engine has 60% more thrust with only a 6% increase in weight. It is presently powering the Ryan Q-2C target drone which recently underwent successful flight tests.

J69-T-25
Latest power plant for the Air Force T-37A twin-jet trainer manufactured by Cessna, the J69-T-25 has increased thrust to 1,025 lbs.

Continental's TC-106 turbine air compressor, developed in conjunction with the United States Air Force, is now available for ground support of jet age aircraft. The unit, supplying low pressure air, is especially suited to engine starting, cabin air conditioning and actuation of electrical generating equipment for ground operations of the aircraft.

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RELIABILITY

(continued from page 31)

Which way do we go? A missile is not designed like a bridge. Twice as much steel framework as necessary may be put into the bridge or a building structure for safety. On this type of structure, you can't afford to take even minimal chances. But a missile is built for performance. Reliability requirements may be less than 90%—something that wouldn't be tolerated where human safety is involved.

The Air Force had to sacrifice reliability for performance in early *Atlas* designs. The nation wanted an ICBM right away. As testing progressed, the missile became more reliable. Now it is an operational weapon.

- **Speed sacrifice**—Peratino reports the Navy was able to take another tack in one weapon system (identity classified). "We found we could increase reliability if we sacrificed speed and range," he said. "We did so because the weapon carries an atomic warhead. The decision, incidentally, also led to the elimination of several parts and the saving of a half-million dollars."

Stewart said the reliability difficulties of the *Vanguard* satellite program stemmed at least in part from the rigid time schedule set by the International Geophysical Year. Programs under less priority pressure, he said, have developed higher degrees of reliability. As an example, he mentioned the Army's solid-propelled *Sergeant*.

"But it isn't necessarily true that all solid-propelled rockets are more reliable," he declared. "First, some solid fuels are unreliable. Second, the only reason some solids are reliable is that they have gone through development testing to make them reliable. The important question is not whether the fuel is liquid or solid but whether the system has had development testing."

In future NASA programs, Stewart said, there will be more on-the-ground development testing and fewer test firings in an effort to improve the reliability score on the shots we take.

We are going to make haste a little more slowly in our space program. American leaders have quietly dropped the talk about immediate trips to Mars and Venus. The major concern of our space program in the near future will be the moon—near misses, moon orbits and hard and soft landings of rocket payloads on the earth's nearest neighbor. NASA Administrator T. Keith Glennan outlined the policy change in a recent Los Angeles speech. He added:

"Some of the firing schedules we developed nine months ago lacked . . . realism."

IAF Papers Cover Space Field

Here are abstracts from some of the most significant documents offered at the recent London Congress by delegates from many nations

by Donald E. Perry and Anthony Vandyk

LONDON—Space medicine and magnetohydrodynamics dominated the technical sessions of the Tenth Annual Congress of the International Astronautical Federation which convened here recently.

But the Congress was by no means limited to these subjects; papers were delivered on practically every field of astronautics interest. As a service to readers, M/R has prepared brief technical abstracts (readers wanting more information may contact the author or the editorial office of MISSILES AND ROCKETS):

Accuracy Limits in Electronic Tracking of Space Vehicles, Paul F. von Handel and Fritz Hoehndorf, AFMDC of ARDC, Holloman AFB, N.W.

The authors predicted that the general trend of further developments in tracking space vehicles will shift toward electronic procedures which promise to achieve the same accuracy without restrictions on weather conditions and time of the day.

Pointing out that electronic tracking of objects moving in the atmosphere is limited by propagation anomalies—limiting use of high precision systems—they recommended frequencies in the kilo megacycle range.

The Technical Realization of Subgravity and Weightlessness, O. Wolczek, Institute for Nuclear Research of the Polish Academy of Science, Warsaw.

The author suggests that an effective way of obtaining smaller gravitation and weightlessness on earth for hours and more could be by centrifuges or devices operating on the same basis. Such devices would be stationed in a vertical position so that their axis of rotation would be paralleled to the earth's surface. Equipment would first serve to investigate force effects on small objects—construction materials, miniaturized measuring apparatus and smaller experimental animals such as mice.

Interplanetary Homing, E. V. Stearns, Lockheed Missiles and Space Division, Sunnyvale, Calif.

A closed loop system of instrumentation was proposed for control of vehicle trajectory in order to give necessary thrust control to place space vehicles in a suitable orbit for final approach. Midcourse trajectory based on knowledge of probable guidance and control accuracies—will have a probable error of about 100,000 miles. As such it must be brought into a landing corridor that is about 10 miles wide at periapsis. Taking into account the strong influence of the destination planet's gravity field. An interplanetary sextant was proposed for the homing task.

Prediction of Man's Performance in Space Using Flight Simulators and Balloon-borne Systems, J. Gordon Vaeth, Technical Staff Member for Man-in-Space, Advanced Research Projects Agency, Washington, D.C.

Vaeth proposed development of advanced forms of ground-based flight simulators and use of long-endurance high-altitude manned balloon flights to determine capability of men to perform in space. By comparing measurements with corresponding data on the ability of automatic equipment to do the same, he said it would be possible to specify and predict those tasks which can be achieved better by manned than unmanned space systems.

'Green' Areas of Mars and Color Vision, Ingeborg Schmidt, Division of Optometry, Indiana University, Bloomington, Ind.

To determine whether the dark areas on the planet are real or not, production of contrasts was studied experimentally by using colored papers simulating the bright and dark areas. It is deduced that a contrast induction is possible on the surface of Mars, depending on hue, brightness and saturation of contrast inducing and contrasting area. He recommended an insulation observation of dark areas as a means which may be helpful in deciding about the real nature of the "green" areas of the planet.

Results of Experiments on the Biological Effects of Cosmic Radiation on Seeds of Hordeum (Gold Barley) Bonus 01518/B19 (Gustafsson), with Special Consideration of Heavy Primaries Effects, J. Eugster, University of Zurich, Switzerland, and Lt. Col. David G. Simons, USAF, Holloman AFB, New Mexico.

Of special interest, is that offspring of three seeds which suffered central hits by heavy primaries (F III/1, F IV/6 and G III/2, exposed in the summer of 1955 at Sault Ste. Marie, developed a color mutation. Grains derived from F IV/6 and G III/2 show a dark brown-dark grey. Those derived from F III/1 have a strikingly light yellow color.

Magnetohydrodynamics and its Application to Propulsion and Re-entry, Rudolf X. Meyer, Space Technology Laboratories, Inc., Los Angeles.

First part of this paper is largely a review of some of the basic concepts of magnetohydrodynamics in continuum fluid mechanics. The theory of the Newtonian approximation to flow is developed, however, in the second part of the paper. Results are presented concerning flow in the shock layer of a re-entry body, and a similarity solution of equations is given for a circular cone in the case of finite and variable electric conductivity.

Re-entry Paths for Manned Satellites, Dr. W. F. Hilton, Hawker Siddeley Aviation Advanced Projects Group, Great Britain.

Of interest is that the author considers that "high drag plus high lift" vehicles will be used for manned re-entry, and that "high drag with zero lift" will be reserved for simple unmanned re-entry, or very early manned flights.

A design study is being carried out at Sir W. G. Armstrong Whitworth Aircraft Ltd. (part of Hawker Siddeley) for a complete project to put two men into orbit (apogee 680 miles, perigee, 80 miles) and for them to land safely back on earth. Calculations were made on the most economical method of achieving a given change of orbit. A report showed by accelerating towards the earth at perigee does not bring the satellite any nearer to the earth, but results in rotation of the axis of the ellipse. It was determined that a small rocket producing lg for 1 second at apogee will lower perigee height by about 20 miles.

Rocket Postal Service, Glauco Partel, Missile Systems Consulting Co., Rome, Italy, and Antonio Angeloni, SISPRE, Rome.

Without entering details about vehicles, propulsion units, auxiliary equipment, the authors discuss dimension, weights, energies required and the magnitude of relative costs of international rocket mail service. Postage for a letter mailed to the U.S. from Europe in 2 hours and 40 minutes would not—if a certain number of daily flights and letters were shipped—exceed $2 per letter.

Motion of An Orbiting Vehicle Subject to Continuous Radial Thrust, Including a Study of Planetary Encounters, Bernard Paiewonsky, Department of Aeronautical Engineering, Princeton University.

Use of such thrust for braking spaceships in planetary encounters is investigated, using one-dimensional potentials. It is pointed out that use of radial braking will produce an increase in the perigee altitude compared with the perigee of the coasting path, a generally desired result. However, due to the extreme sensitivity of predicted perigee distance in close approaches to planets, en route measurements of the navigation and guidance equipment for both a radial braking system and the impulsive thrust correction system, will require the same high degree of accuracy. It is concluded that one system does not seem to have any overwhelming advantage over the other.

Some New Methods of Satellite Orbit Calculations and Stability Problems, Herbert Knothe, AFMDC, Holloman AFB, N.M.

Equations of motion for a satellite in a rotationally symmetric gravity field are reduced to systems of ordinary first order differential equations. A rapidly convergent process of iteration for solving these equations is explained and examples are given. The author supplies a differential geometrical approach giving formulae for the calculation of regression.

Design Study of An Earth Satellite Evolving from a Four-Step Solid Propellant Rocket Vehicle, S. K. Kumar and B. R. Rau, Indian Astronautical Society, Mysore, India.

The authors point out that countries like India cannot afford large scale liquid propellant rocket research and any progress or contributions from such countries in space exploration will have to be through solid propellant rockets. But this isn't keeping the nation from a novel space exploration approach.

While planning for launching a 50 Kg satellite, they also want to place a solid propellant rocket on top of the satellite section which would be intended to escape the earth after the satellite has gone into orbit. The experiment would show the possibility of orbital launching.

Launching Conditions and the Geometry of Orbits in a Central Gravity Field, Fang-Toh Sun, Taiwan Provincial Cheng Kung University, Tainan, Taiwan.

Formulas relating the principal geometrical parameters of the orbit to the launching parameters at final burnout are developed. Treatment is given to the elliptic, the parabolic and the hyperbolic types of unperturbed orbit. Problem of burnout precision is briefly discussed, and an energy-momentum diagram shows the essential geometrical aspects of possible orbits in a single chart.

Theory of the N-Step Relativistic Rocket, M. Subotowicz, Polish Astronautical Society, Warsaw.

This gives the theory of the relativistic multistage rocket necessary for the far future flights to the stars. A differential equation describing mass and velocity changes is defined along with its optimization possibilities. The author accepts that all stages would be analogous and all engines would use the same jet mass. Such a stage rocket would have only one reaction chamber, used in turn by all steps.

Problems of Magnetic Propulsion of Plasma, Ralph W. Waniek, Giannini Plasmadyne Corp., Santa Ana, Calif.

The paper deals with theoretical problems and experimental results obtained during a study aimed at accelerating ionized gases by strong transient magnetic fields. Techniques of these fields are discussed with their possible application to high field plasma thrustors. The author shows special air-core magnet configurations and outlines their characteristics as intermittent plasma propulsors. He contends that such thrusts might likely have a useful place in future space vehicles.

Application of Solid Propellants to Space Flight Vehicles, H. L. Thackwell, Jr., Grand Central Rocket Co., Redlands, Calif.

The author gives preliminary design calculations for a three-stage, all propellant vehicle called the *Envoy* which, when ground-launched, could send a 50-pound payload to the moon or place a 230-pound payload into a 300-mile high orbit. The vehicle would weigh 17,000 pounds and would be 37.8 feet in height. He anticipates that *Envoy* would cost considerably less than the $500,000 figure for the *Scout* or $1 million for a single *Thor* liquid booster.

Minimum Energy Requirements for Space Travel, Harry O. Ruppe, ABMA, Huntsville, Ala.

By calculating minimum energy requirements for many space missions and expressing them as velocity requirements of a rocket vehicle, the author comes up with a preliminary outline of an optimum vehicle, or for approximation of the payload capability of a given vehicle.

Measurement of *Jupiter* Re-entry Radiation, David D. Woodbridge, and Warren N. Arnquist, ABMA, Huntsville, Ala.

This is a detailed report on the Army's Operation Gaslight, the name given to the re-entry radiation measurement program of ABMA. Through industry participation, preliminary radiometric and photographic measurements have been made from the PbS infrared limit to the near ultraviolet. Extensions to cover the 3-5 micron band are in progress. Re-entry velocities begin at about Mach 14, which corresponds to an adiabatic shock front temperature of nearly 4000°K. Difficulties of operations are mentioned and the coordination of instruments at several locations with timing circuits is described.

Unsteady Compressible Magnetic Laminar Boundary Layers in Hypersonic Flow, Paul S. Lykoudis and John P. Schmidtt, Allison Division, General Motors Corp., Indianapolis, Ind.

This considers the unsteady hypersonic flow of a compressible, viscous, thermally and electrically conducting fluid in the presence of a magnetic field. The authors show that under reasonable restrictions the equations of conservation of total mass, energy, and momentum may be brought into similar form.

Determination of Air Density and the Earth's Gravitation Field from the Orbits of Artificial Satellites, D. G. King-Hele, Royal Aircraft Establishment, Farnborough, England.

Taking into account the oblateness of the earth and atmosphere, the tumbling of satellites and rotation of the atmosphere, the author gives methods for evaluating density at heights between 200 and 400 Km. Variation of density is traced with time.

On the Apparent Motion of An Earth's Artificial Satellite, J. J. de Orus, Fabra Observatory, Barcelona, Spain.

The author points out that a primary problem in radio observations of an artificial satellite of determining the time when the satellite is at its minimum distance from a determined earth station. He points out that this time calculation is simplified owing to the feeble flattening of the terrestrial globe and the little relation between the periods of revolution of the satellite and the earth's rotation.

Nuclear Rocket Missions and Associated Powerplants, John J. Newgard and Myron M. Levoy, Reaction Motors Division, Thiokol Chemical Corp., Denville, N.J.

Requirements of open cycle nuclear power plants for a number of terrestrial escape to orbit and space missions are given. Missions analyzed include single-stage, large payload, nuclear boosted escape vehicles; chemically boosted second-stage nuclear rockets escaping with large pay-

PILOT PERFORMANCE
A SPECIALTY AT VOUGHT

Ten miles high, at 1,000-plus mph, pilots will fly "in their shirt sleeves."

A protective capsule will take over the job of providing environmental protection of the flier. No longer will he need to encumber himself with oxygen mask, pressure suit, personal parachute, bail-out oxygen bottle, life jacket and raft and other survival gear. Sealed off in his protecting "thermos bottle," the pilot also is provided a highly advanced emergency escape method: the entire capsule can be detached from the airframe and gently parachuted to the ground.

Chance Vought conceived this system and now is developing it under contract. The advanced capsule is typical of the human factors progress Vought stands for.

This company has won its reputation largely through its own aircraft. As speeds vaulted above 1,500 mph, Vought learned to design cockpits of very high density. Meeting stringent carrier requirements in the design of *Crusader* series fighters, company engineers developed an exceptional feel for balancing high and low speeds in a single vehicle.

This experience is ideally suited for human factors work in spacecraft, as Vought has already proved in specific applications on projects under contract.

Today, in a space-oriented Cockpit Laboratory, Vought is working out the details of pilot seating, instrument displays and manual controls to make man not only a passenger, *but an operator,* of spacecraft.

Piloted aircraft, along with atmospheric missiles and antisubmarine warfare, are specialties in Chance Vought's Aeronautics Division. Other major interests are being aggressively advanced in the company's Astronautics, Electronics, Research, and Range Systems Divisions.

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STILL A PILOT'S AIR FORCE

His plane looks like a missile. It carries missiles. It is an automatic machine itself – almost to the point of push-button control. But the Air Force pilot gives his aircraft *discretionary* guidance – a generalship that pilotless weapons can't match. Along sensitive borders today, we depend on pilot judgment and reason to keep our guard up without overstepping. The pilot's combat reliability is the foundation of our "mixed forces" concept of deterrent strength through missiles and manned weapons. And getting this keen observer out into space is the immediate goal of U. S. space-science efforts.

AERONAUTICS ASTRONAUTICS ELECTRONICS GENESYS CORP RANGE SYSTEMS RESEARCH

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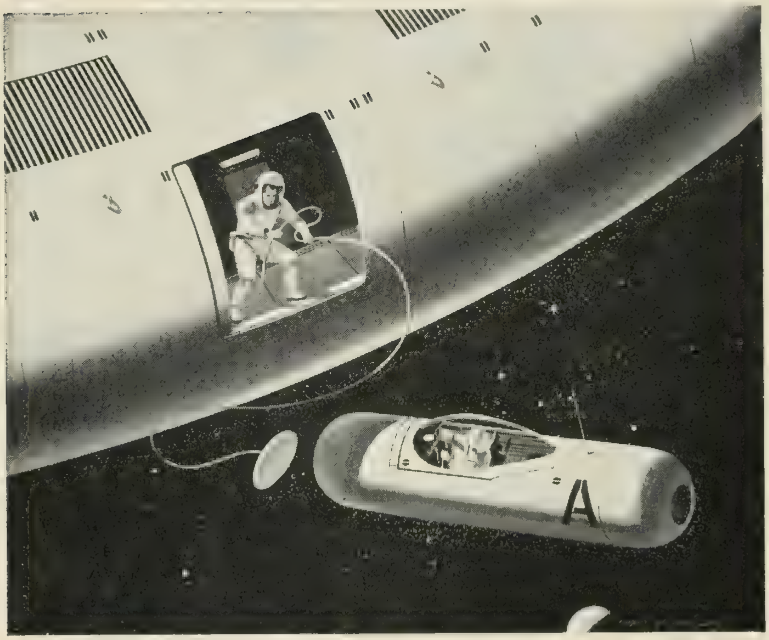
COUNT DOWN!

for the conquest of space



WHAT KIND OF ENGINE FOR A SPACE-TAXI?

It takes a unique engine to jockey a space-taxi in for a landing on an orbiting space station—one that will give a space pilot instant control and precise maneuverability.

Such an engine is the fully controllable rocket engine—ideal for space travel yet as easy to operate as an automobile engine.

The rocket engines are ready now

Although the space-taxi is still a gleam in an engineer's eye, the controllable rocket engine is available now...and has immediate application for existing aircraft. The pilot of a plane with auxiliary rocket power can switch it on for sudden, swift acceleration at high altitudes . . . the aircraft's air-breathing turbojets supplying power for ordinary flight operations. This is the mixed-power theory. Since World War II several mixed-power concepts have been developed in foreign countries, including Russia, France and England.

Extra power for today's aircraft

Rocketdyne already has designed, tested, and manufactured rocket engines for mixed power applications. The AR-1 rocket engine is a liquid-propellant system, as are the large power plants for the Atlas, Thor, Jupiter, and Redstone ballistic missiles. The AR-1 passed stringent flight tests as a supplementary power plant on modern jet aircraft. Substantial improvements over normal near-sonic speed and 50,000-foot altitude capabilities were demonstrated in more than 100 test flights.

The AR-2, second in a series of four rocket-engine models developed by Rocketdyne, is a fully-throttleable engine that provides varied thrust. Using fuel from the airplane's tanks—which automatically ignites with hydrogen peroxide—these engines have full stop and restart capability.

More value for taxpayers' money

The auxiliary rocket engine gives present aircraft superperformance capabilities at a relatively low cost. It provides the increased speed and maneuverability that could spell the difference between the success or failure of an intercept mission. Almost any existing jet aircraft, as well as those now on the drawing board, can be adapted readily for AR engines.

Looking forward to tomorrow

Beyond a doubt, rocket power has a leading role in the Free World's future. Rocket-propelled airplanes, such as the X-15, will pave the way for man's entry into Outer Space. The multi-million-pound-thrust systems that are now under development at Rocketdyne will be man's means to explore interplanetary Space. But meanwhile, these rapid advances in rocketry can add great strength to America's present deterrent arsenal.

THE MEASURE OF ROCKET POWER

The liquid-propellant AR rocket engines are "static tested" at Rocketdyne's field laboratory to measure thrust and performance.

FIRST WITH POWER
FOR OUTER SPACE

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

oads, and terrestrial orbiting nuclear vehicles capable of moving into far space. Important is the analyzation of a "family" of ydrogen cooled, solid-fuel graphic element, graphite core moderated, BeO reflector moderated reactor power plants.

Practical Investigation of Spaceship Control Problems, C. A. Cross, 284 London Road, Northwich, Cheshire, United Kingdom.

The author describes equipment that has een used to investigate manned spaceflight echniques. The spaceship flight simulator onsists of a control panel, an electro-mechanical computer, and a planetarium type rojector. A pen in the computer duplicates he motion of the spaceship on a scale of ne inch to 70 miles. The pen controls a eference sphere projector which simultaneously plots the position on a chart 10 inches quare. The ship can be turned at rates of p to 2 RPM by firing torque jets, and aiming trials have shown that the standard eviation of the main propulsion rocket notor is 1.65°. Some 20 flights have been nade to determine a pilot's ability to carry ut a simple circumnavigation of a luminous eference sphere 22 miles in diameter in the niddle of a 700 mile square navigable area. rials show that the ship cannot be flown uccessfully by direct instinctive interpretation of the projected display and it must e navigated from start to finishing by deducing its position in space from the observations, plotting this on a chart, and aking the control action needed.

he Biological Satellite, R. P. Haviland, eneral Electric Co., Philadelphia.

This is a proposal for a biological satellite to investigate problems of weightlessness and radiation exposure. The author ives conceptions of three different vehicles nd outlines the experiments possible. Specific research areas would include adaption o zero-G; learning of locomotion under ero-G condition; free maneuvering in pace; effect of exposure to energetic participles, and effect of photon radiation. hree classes of living subjects would be tilized: fruit fly (long term exposure to adiation); mice and rats (radition effects n the organisms and future generations); ailless type primates (probably Rhesus nonkey and Chimpanzee) radiation effects ut mostly adaptability to zero-G).

Rocket for Manned Lunar Exploration, I. W. Rosen and F. C. Schwenk, NASA, Vashington, D.C.

The authors recommend that a "bold" pproach be taken to lunar exploration by tilizing the capabilities of man in the *Vova* vehicle and keeping instrumentation t a minimum. (See M/R *Aug. 31, p. 24*).

unar Exploration by Photography from Space Vehicle, Merton E. Davies, RAND Corp., Santa Monica, Calif.

A panoramic camera which should get ictures superior to those obtained by telescope or TV, is advocated. The camera vould utilize the lunar vehicle's spin stabilization to perform scanning. However, the ehicle would have to sense its spin rate nd the approximate direction of the round.

aboratory Experimental Studies in Re-entry Aerothermodynamics, Walter R. Varren, General Electric Co., Philadelphia, Pa.

A criticism of the capability of present aboratory test facilities to undertake future nvestigations of re-entry problems is made. He postulates that the arc-heated wind unnel, because of desirable characteristics, vill have a higher potential than other acilities in the study of re-entry aerothermodynamics.

Space Power, William W. T. Crane, Martin Co., Baltimore, Md.

Safety packaged isotopic power supplies can be built—the author maintains—during the next few years to produce eight watts per pound and at significantly higher efficiencies than 5 or 6%. The author contends that only four isotopes—Curium-242, Polonium-210, Curium-244 and Plutonium-238 have merit as heat sources.

Sterilization of Space Vehicles to Prevent Extraterrestrial Biological Contamination, Richard W. Davies, Marcus G. Comuntzis, Jet Propulsion Laboratory, CalTech, Pasadena, Calif.

The authors maintain the introduction of terrestrial organisms and contaminants might so distort the biology of plants as to constitute a scientific catastrophe. They believe it is feasible to sterilize probes so that loss of information to future investigators is minimized. Recommended methods are use of ethylene oxide, heat and radiation, accompanied by the sterile assembly of special components. They recommend that pollution tolerance be kept to 10^{-8} dead bacteria per missile, and that infection tolerance be less than 10^{-6} per missile for the planets and 10^{-1} for the moon.

Differential Expressions for Low-Eccentricity Geocentric Orbits, Samuel Herrick, L. G. Walters and C. Geoffrey Hilton, Aeronutronic Systems, Inc., Glendale, Calif.

The authors derive differential expressions that are applicable to correction of low-eccentricity orbits and the evaluation of uncertainty in the knowledge of the orbits.

Some Remarks on the Optimum Operation of a Nuclear Rocket, G. Leitmann, University of California, Berkeley, Calif.

Nuclear rockets in which energy source and working fluid are separated come in for modification by the author. He includes the constraint arising from their energy-limited nature and derives an exhaust speed program which is shown to be independent of mass flow rate. He finds that the characteristic speed corresponding to the optimum exhaust is a function of total working fluid mass only and that it increases as the working fluid mass increases.

Secular Variation in the Inclination of the Orbit of Earth Satellites (1957) and Air Drag, L. N. Rowell and M. C. Smith, RAND Corp., Santa Monica, Calif.

A plausible explanation of this phenomenon, according to the authors, is the component of drag acceleration normal to the orbital plane arising from the rotation of the earth's atmosphere in the same sense as the satellite. This component causes the inclination of the orbital plane to decrease. Rate is found by equations.

Effects of a Meteoroid Impact on Steel and Aluminum in Space, R. L. Bjork, RAND Corp., Santa Monica, Calif.

This paper is largely confined to estimating the effects of a collision between an individual meteoroid and some component of the vehicle. He attempts to calculate the phenomenology of an impact of meteoric velocities from fundamental principles and makes only simple assumptions which may be justified.

Impulsive Midcourse Correction of an Interplanetary Transfer, R. J. Gunkel, D. N. Lascody and D. S. Merrilees, Douglas Aircraft Co., Inc., Santa Monica, Calif.

By surveying possible ballistic trajectories from earth to another planet and paying attention to sensitivity to initial condition errors, the authors indicate that initial condition tolerances can be maximized by careful choice of trajectory. They consider the possibility of midcourse correction to compensate, and give the relationship between correction impulse requirements and sensitivity to initial conditions. They conclude that approximate methods can be suitable for determining basic trends but there is a necessity for using more accurate solutions for design purposes.

Ionospheric Scintillations of Satellite Signals, H. P. Hutchinson and P. R. Arendt, U.S. Army Signal Research & Development Laboratory, Fort Monmouth, N.J.

Techniques using doppler shift and direction-finding may prove to be most useful tools in further studies in the ionosphere and space, the authors believe. They point out that short-time variations of satellite-emitted radio signals can give a good measure of the roughness or inhomogenity of the ionosphere. Variations are more noticeable, they point out, at the low frequencies—20 and 40 mc's than at the higher ones, but the scintillations are not negligible at 10 mc's, the frequency most commonly used for determining position of previous U.S. satellites.

On the Corridor and Associated Trajectory Accuracy for Entry of Manned Spacecraft Into Planetary Atmospheres, Dean R. Chapman, NASA, Moffett Field, Calif.

An analysis is developed that determines the corridor through which manned spacecraft must be guided in order to avoid excessive deceleration for human occupants and yet to encounter sufficient deceleration for completing entry. Introduced is a dimensionless parameter coupling the aerodynamic characteristics of the vehicle with certain planetary characteristics evaluated at the perigee altitude corresponding to the approach conic trajectory.

Methods of Analyzing Observations on Satellites, G. V. Groves and M. J. Davies, Department of Physics, University College, London.

The authors develop a theory for the precise determination of the elements of a satellite orbit from observational data. Account is taken of the effects of atmospheric refraction, aberration, the finite speed of light and the difference between geocentric and geographic latitude.

The Three-body Problem, Earth, Moon, Spaceship, W. Grobner and F. Cap, Innsbruck University, Austria.

The solution of the astronomical n-body problem using Lie series is discussed and the known algebraic integrals—conservation of momentum, angular momentum and energy—are reproduced. There is a thorough discussion of the initial data, the closed solution of the three-body problem is given, and two different methods for numerical computation are furnished.

On the Flight Path of a Hypervelocity Glider Booster by Rockets, Angelo Miele, Purdue University, Lafayette, Ind.

This article investigates the flight of a vehicle operating along an equilibrium trajectory—where weight is balanced by lift plus the centrifugal force due to the earth's curvature. It is shown that the path which maximizes the range includes: an initial sub-arc in which all the propellant mass is expended at the engine's maximum burning rate, and a final sub-arc in which the glider coasts at variable altitude in such a way that aerodynamic drag is a minimum.

Tracking Objects Within the Solar System Using Only Doppler Measurements, Robert R. Newton, Applied Physics Laboratory, Silver Spring, Md.

It is assumed that an artificial planetoid emits radiation of reasonably stable frequency which can be received by an earth tracking station. He finds that without using any information except the time dependence of the Doppler shift, that orbital elements can be completely determined with a precision of about five significant figures, during one-half day's tracking from one station. He believes that the effective range for Doppler tracking should be at least 50 million kilometers.

Recent Developments and Designs of the Ion Rocket Engine, R. H. Boden, Rocketdyne, Canoga Park, Calif.

The author reveals that an ion thrust device directed toward a prototype engine configuration has been in operation at his company for several months, producing quantitative measurements of thrust. He believes a flyable ion engine, delivering less than one pound of thrust, could be available in five years, utilizing a propellant such as cesium.

Personnel Selection and Training for Space Flight, Brig. Gen. Don Flickinger, ARDC, Andrews AFB, Washington, D.C.

The author discusses recruitment and training of crews for manned orbital flight, pointing out that the determination of an individual's psycho-physiologic fitness comprises a major task for the behaviorists, the physiologist and the flight surgeon. Medical evaluation, stress tolerance testing and indoctrination would require 18 months for a candidate.

ARMY RESEARCH OFFICE

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ARMY RESEARCH OFFICE

Sedov Elected as IAF Head

by an M/R Correspondent

LONDON—The United States, which dominated the International Astronautical Federation for 10 years, has lost all but two of the principal offices of the organization—probably on purpose in a bid to encourage world astronautics cooperation.

At the closing sessions of the IAF Congress here, Soviet Academician Leonid Sedov was elected president of the federation. He is the first Russian to win that honor.

Sedov, who headed the U.S.S.R. delegation to the Congress, is the son of a mining engineer. After becoming a theoretical mathematician, he won the Stalin Prize in 1952. He is also president of the Interplanetary Commission of the Soviet Academy of Sciences.

Elected as IAF vice presidents were Medicin-General J. P. Bergeron of France, Dr. Leslie Shepherd of Britain, Col. John Stapp of the United States, Eugen Sanger of Germany, and A. M. Hjertstrand of Sweden.

Andrew Haley of the United States was selected as chairman of the group's new General Council.

Dr. Theodore von Karman was chosen chairman of the committee to form the first IAF International Academy of Astronautics, which will have about nine members. Among those mentioned for early election to the academy were Dr. Wernher von Braun, Dr. James Van Allen and Dr. Hubertus Strughold.

The next meeting will be held in Stockholm, and the following one in Denver. Buenos Aires was suggested for the 1962 meeting.

At Farnborough

U. K. Reported Testing AAM Similar to *Eagle*

by an M/R Correspondent

FARNBOROUGH, ENGLAND—Britain is flight testing an air-to-air missile which should provide valuable information for the U.S. Navy's **Bendix** *Eagle* program, U.S. sources disclosed here during the twentieth annual Farnborough air show.

De Havilland Propellers is reportedly doing the development on the AAM, which carries the code name "Red Top." It is said to have infrared guidance, using a cooled lead telluride cell receiving in a 4 to 5 micro range; the U.S. Navy's *Sidewinder*, by comparison, uses lead sulphide with a 2 to 4 micro range.

According to reports, the bird carries a 68-pound non-nuclear warhead, has a 14,000-yard range, and is designed to be carried aboard the de Havilland Sea Vixen. It probably is an advanced version of the *Firestreak*.

American military observers said technological exchange resulting from the tests should lead to earlier availability of the *Eagle*. De Havilland would not comment.

Neither would **English Electric** comment on a report that it was working on an all-solid, surface-to-surface, fully transistorized tactical Army missile in range between the *Lacrosse* and the *Sergeant*.

This year's Farnborough show included a 40% larger missile display than last year. The *Black Knight* and the Australian-built *Malkara* SSM were put on public exhibition for the first time and a 25-foot model of the de Havilland *Blue Streak* was shown. English Electric, in cooperation with **Minneapolis-Honeywell Regulator,** showed a 27-pound miniature stabilized platform less than a cubic foot in volume, with a life of 1000 hours, storage capability up to five years, and ability to withstand 40 G's of shock and linear acceleration of 30 G's at temperature of minus 65° to 180° F.

A cutaway of **Bristol Siddeley Engines,** Thor BT-1 Ramjet for the *Bloodhound* was also shown for the first time.

Avro Weapon Division of the **Hawker Siddeley Group** announced full-scale test of *Bluesteel*, counterpart of the U.S. *Hound Dog*.

Congress Approves Medal Honoring Robert Goddard

WASHINGTON—President Eisenhowe is expected to sign soon a bill to provide a gold medal in honor of the lat Prof. Robert H. Goddard, known a the "father of modern rocketry."

The Senate passed the legislatio and sent it to the White House las week. The bill authorizes $2500 fo the medal.

Goddard, who died in 1945, di pioneer work in experimental rocketr in the early part of this century.

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V. J. Braun

V. J. BRAUN, ASSISTANT DIRECTOR FOR PLANNING
ENGINEERING DIRECTORATE

V. J. BRAUN

SYSTEM DEVELOPMENT CORPORATION

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SANTA MONICA, CALIFORNIA • LODI, NEW JERSEY

• VANDERBERG AFB, CALIF.—A SAC crew for the first time fired a **Convair** *Atlas* at 1:49.5 P.M., EDT, Sept. 9 giving the United States its first operational ICBM. The big missile roared 4300 miles westward across the Pacific Missile Range and landed near Wake Island.

• DOWNEY, CALIF.—The Navy announced successful completion of laboratory tests on the vitally-important inertial navigation system for *Polaris* submarines. It said a prototype engineering model will now be tested aboard the USS Compass Island, the *Polaris* program's surface test ship.

• WASHINGTON—The Army Quartermaster Corps plans to buy more than 1000 more German Shepherd dogs during the next 10 months for sentry duty at *Nike* and other missile sites throughout the nation.

• MCGUIRE AFB, N.J.—The first operational *Bomarc* a missile squadron joined the nation's anti-aircraft defense forces. The 60-odd nuclear-tipped **Boeing** missiles have a 200-mile range.

• EGLIN AFB, FLA.—Air Force officials said the 400-mile range *Bomarc B* is expected to be operational in about 15 months. Tests are being conducted at both Eglin and Cape Canaveral.

• EDWARDS AFB, CALIF.—Stoppage in the LOX lines forced cancellation of the first powered flight of the *X-15* rocket plane. Trouble occurred Sept. 4 after the plane was aloft and about to be released from a B-52 at 38,000 feet for a low altitude, low-speed run.

• WASHINGTON—One of the Navy's new *Terrier* guided missile frigates authorized in the FY 1960 budget will be named after the late fleet Admiral William F. (Bull) Halsey.

• WASHINGTON—Construction funds for hardened *Mace* sites were excluded from the compromise House-Senate $1.3-billion military construction program for FY 1960. Air Force was directed to draw on prior funds if a decision is made to go ahead with *Mace*. Under the measure AF gets $777 million; Army—$263 million and Navy—$204 million. So-called "no-year" funds of $57 million were provided to cover outstanding *Bomarc* and *Nike-Hercules* construction projects.

'Mobot' Developed To Handle 'Hot' Materials

ALBUQUERQUE, N.M.—Even Tom Swift would probably be amazed at the new "Mobot Mark II" just developed by **Hughes Aircraft Co.** The mobile robot with hydraulic muscles and closed-circuit TV eyes, will be used at Sandia Laboratories here to handle dangerous materials in radioactive environments. It will be remotely controlled by an operator safely out of the "hot" area behind dense concrete walls.

Mobot can pick up and move large heavy objects in and out of radioactive test rooms. It can handle hand tools for assembly and dismantling of equipment under test, and operate machine tools.

Constructed on a powered chassis resembling a fork truck, Mobot has a vertical reach of ten feet and a horizontal reach of three feet. The hydraulic handling arms can lift 150 pounds and the lift platform 1500 pounds. It weighs 4500 pounds and is controlled through a 200-foot cable. This first model is designed for indoor use but outdoor types are deemed practical.

Mobot's designers predict great potential for the mechanical marvel in the space age. One suggested possibility is in lunar exploration. Such a unit, remotely controlled from earth, could collect samples, run tests, and explore on command.

Other possibilities include underwater exploration and all manner of reactor refueling, waste disposal, and decontamination operations.

New Strides Made in Liquid Hydrogen Handling

BOULDER, COLO.—Several new developments in liquid hydrogen storage and transportation facilities were disclosed last week by Dr. R. H. Kropschot of the National Bureau of Standards' Cryogenic Laboratory here.

An evacuated powder, silica aerogel-aluminum, having twice the heat conductive resistance of powders previously analyzed, would provide a relatively cheap and convenient insulation for liquid hydrogen transportation trucks.

Another development reported is a multiple-layer insulation system with four times the heat-flow resistance of the best evacuated powders. This method, more expensive than the powder technique, consists of alternating layers of poor conductors and good reflectors.

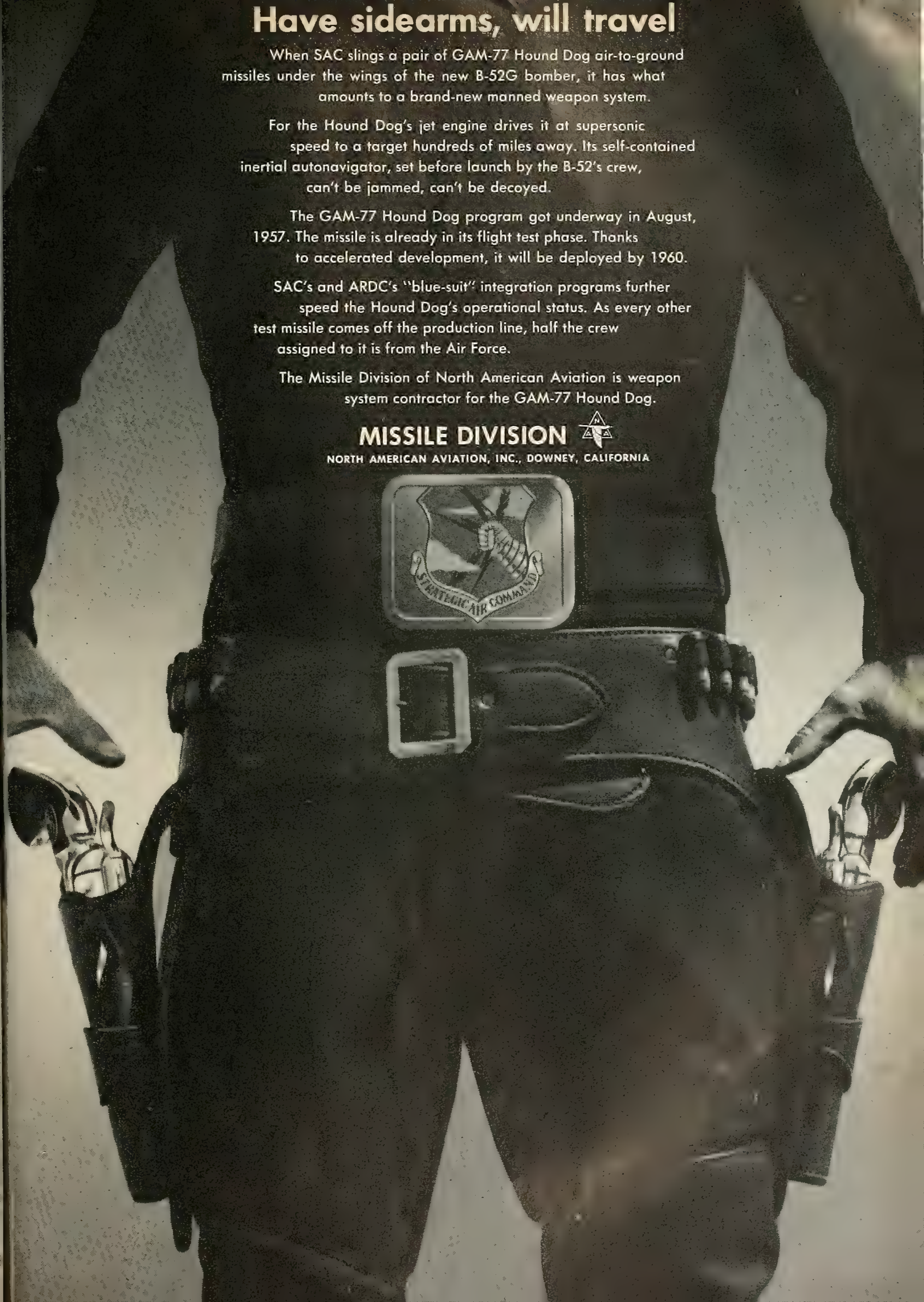
Combination of the multiple-layer concept with an intermittent, high-vacuum system would result in low heat-leak transfer lines of long service duration. Carbon dioxide inserted in an annular space around the line would condense when cryogenic fluids were introduced, producing the vacuum.

Engineer D. A. Van Gundy pointed out that any hydrogen gas leakage would be adsorbed by the carbon dioxide and that the high-vacuum insulation occurs only when the line is in use.

Screen Show Missiles Small as .22 Bullets

WILMINGTON, MASS.—A new catadioptric light screen sensitive to hypervelocity projectiles as small as .22 caliber has been developed by **Avco's** RAD Division here. Used in ballistic range hypervelocity instrumentation, the screen is part of shadowgraph equipment for recording missile attitudes and aerodynamic flow. The system allows exposure times in the order of 10-7 and 10-8 seconds.

• DAYTON, OHIO—Scientists at Wright Air Development Center are testing the reactions of airmen who spend two-day periods in a broomcloset-size land-based space capsule. Some 40 airmen are expected to take part.



Have sidearms, will travel

When SAC slings a pair of GAM-77 Hound Dog air-to-ground missiles under the wings of the new B-52G bomber, it has what amounts to a brand-new manned weapon system.

For the Hound Dog's jet engine drives it at supersonic speed to a target hundreds of miles away. Its self-contained inertial autonavigator, set before launch by the B-52's crew, can't be jammed, can't be decoyed.

The GAM-77 Hound Dog program got underway in August, 1957. The missile is already in its flight test phase. Thanks to accelerated development, it will be deployed by 1960.

SAC's and ARDC's "blue-suit" integration programs further speed the Hound Dog's operational status. As every other test missile comes off the production line, half the crew assigned to it is from the Air Force.

The Missile Division of North American Aviation is weapon system contractor for the GAM-77 Hound Dog.

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soviet affairs . . .

By DR. ALBERT PARRY

If *Lunik* for Mikoyan, what for Khrushchev? . . .

It would be just like Khrushchev to prepare a "first" in rocketry before he leaves for the States, so as to make news at the exact time of his meeting with President Eisenhower in Washington. Be it the first successful Soviet hit on the moon, or the first Russian man in space, the headlines would be vastly more effective if Nikita happened to be on U.S. soil at the moment. Remembering that *Lunik* was launched last January while Mikoyan was visiting here, one may guess that Khrushchev's scientists may have orders to try, anyway.

Why has he vetoed a rocket-base visit exchange? . . .

The likeliest explanation is Khrushchev's fear that Ike, being a general, would learn more from a look at a Soviet rocket establishment than Khrushchev, a civilian, could gather from an inspection of a similar U.S. installation.

Of course, Khrushchev's 24-year-old son Sergei, who is accompanying him to America, has a job in the Soviet missiles and rockets effort. Unlike Nikita, he speaks some English. Conceivably he could be of some use to his dad on a tour of one of our rocket bases. But, from what we hear, Sergei is too new at his rocketry to be much help.

As propaganda, Nikita's 'peaceful' refusal . . .

to see U.S. rockets may be more valuable to Khrushchev than any satisfaction of his curiosity about our plants and bases. Here are quotes from his "explanation" to some questioning Americans of why he would neither visit a U.S. rocket base nor invite President Eisenhower to view a similar Soviet base:

"You (Americans) want to add a bad taste to our meetings. If we would go journeying to each other in order to sneak a look at who has what sort of rockets and just where they are located, then it all comes down not to peace but to war preparations. But our aims are different. I am going to the U.S.A. with full knowledge that they have pretty strong military means. And even if I am offered a view of, say, rocket-paunching pads, I will decline."

The Soviet premier continued: "I think that were we to include, in the sojourn of the President of the U.S.A. in our country, visits to the points where we make our rockets and where these rockets are located, the President could have said: 'For what did you invite me? To frighten me? . . .' On our part this would not have been hospitable. Therefore we will not permit ourselves to offer to the President anything of the kind."

No 'rockets in the pockets' . . .

is Khrushchev's cry. He declared that "all of us—Russians, Ukrainians, Belorussians, Kazakhs, all the peoples of the Soviet Union—are very hospitable." He recited a list of national dishes, from various Soviet regions, that he could offer to such an honored guest as Ike. "We have many tasty dishes, please—we won't refuse anything to our guests. But the main thing, in our sincere and hearty conversations we must convince (Americans) that we do not plot anything bad against the United States and other countries. But if, during my talk with the President, a rocket would peep out of one of my pockets, and another rocket from another pocket, what kind of hospitality would that be, what kind of talk?"

Check 'em in the vestibule . . .

Khrushchev concluded: "Time was when on coming to negotiations people left their weapons in the vestibule. Talks were weaponless. But here you want us, after we have invited the President of the U.S.A. for a conversation about peace, to show to him the places where we make our rockets and where we launch them." This, said Nikita, would be "absolutely inadmissible."

House Group Urges More R&D

WASHINGTON—The House Space Committee has charged that the Administration isn't spending enough money on military research and development.

The committee also is hitting out at pressures within the Pentagon and Administration to narrow the participation of the Army in space (M/R Aug. 31).

The committee made its position clear on both issues in a newly issued report called "Basic Scientific and Astronautic Research in the Department of Defense."

The report called on the Administration to review its military R&D budgetary policies "at the earliest practical time."

"In view of the swift scientific pace going forward today, research and development money clearly seems inadequate," the report said. "This is the case apparently at all levels of military government."

The committee specifically hit at the amount of R&D money that is being made available to the Army and Navy.

"The amount allocated for research within the total Administration budget appears inadequate," it said. "The amount allocated to the Army within the Defense Department budget appears inadequate. And the amount allocated by the Army within its own budget may also be inadequate . . ."

As for the Navy, the committee said at present R&D funds make up only 8.5% of the Navy budget for FY 1960 and recommended the amount be increased to "10% or so." The price tag—more than $150 million extra.

The 1960 Navy budget provides $970,920,000 for R&D—$522 million of it for basic and supporting research.

The committee said pointedly: "National security today is as dependent upon research as Elizabethan England was dependent upon the fleet of Sir Francis Drake."

Turning to space, the committee noted "the actual capability of all services to use space is still in its formative stages" and "many scientific answers in relation thereto are unknown."

Therefore, it said "a duplication of research and development effort in these fields is by no means unwarranted but is, in fact, essential in many cases."

It specifically said the Army has "interests in space which warrant vigorous and expeditious research in such allied areas as the use of space or space vehicles for communications, weather interpretation, surveillance, reconnaissance and the like."

The committee also recommended that:

- The Defense and State Departments "immediately take steps to speed up effective liaison with outstanding scientists and science programs in other countries."
- The United States seriously consider strengthening its defences against missile-launching submarines by prohibiting foreign submerged submarines from operating within 200 miles of U.S. coasts.
- The Air Force must find means to increase and stabilize its pool of in-house R&D talent.

Tests Show Progress With Mercury Capsule

CAPE CANAVERAL—*Big Joe* test results last week indicated that the *Atlas* ICBM has developed a new problem but that major components of the project *Mercury* space capsule are well on their way towards becoming operational.

The *Atlas* booster's two outside engines failed to separate, considerably reducing the planned range and altitude. Air Force officials said it was the first time this malfunction had occurred.

The boiler plate capsule's retrorockets used to insure clean separation of the capsule from the *Atlas* booster fired as programmed, and the nitrogen control jets pivoted the blunt end of the capsule down into proper position for descent.

The capsule was picked up by a destroyer.

Designated the *Big Joe* tests, the capsule was to have been hurled to an altitude of 100 miles and a speed of 17,250 mph in order to test components against maximum heat and reentry shock.

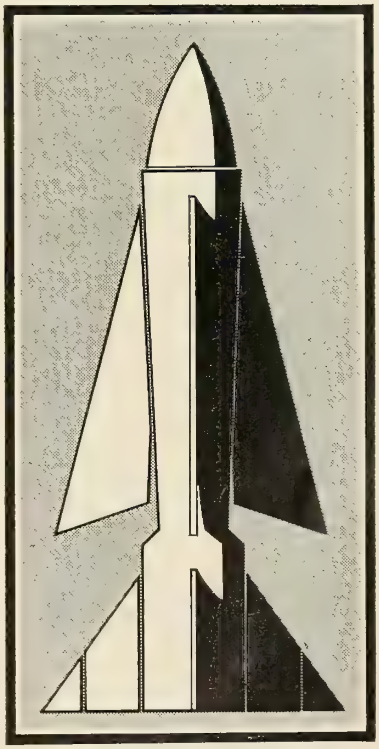
Artificial 'Lightning' Used To Shape Metals

FARMINGDALE, L.I.—Man-made "lightning" has been harnessed by **Republic Aviation** engineers here to shape high-strength metals. The "spark bomb," as it is called, converts electrical energy directly into mechanical power. It offers the possibility of a small cheap metal-forming tool that could replace conventional hydraulic presses that cost a half-million dollars and require large floor space.

In operation, electric power is stored by a battery of capacitors. This energy is released in 40 millionths of a second under water, creating a high-velocity shock wave that stretches the metal back into the desired shape. Presently, about 600 horsepower has been realized with the technique; hopes are for much higher power levels.

According to Republic scientists, the technique is particularly valuable for forming newer steel and titanium alloys and other advanced materials which have practically no stretchability. Such materials require complicated equipment of tremendous force to shape them to the close tolerances and smoothness required.

Eagle Is Depicted



THE NAVY's *Eagle*, seen in this artist's conception, is a nuclear-tipped high-speed missile designed for launch against aircraft from relatively low-speed carrier planes. The Bendix missile, with a range of about 100 miles, is under research and development.

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missile business . . .

BY WILLIAM E. HOWARD

Quick response in getting industry to solve some of its tougher technical problems is reported by the Navy's BuWeap (formerly BuOrd and BuAer). Back in April, BuOrd handed representatives of 200 major companies a book detailing about 200 of the most pressing research needs, and telling why they were roadblocks to the development of superior weapons. Much to the Navy's amazement a half-dozen firms have already come in with tentative solutions to about 25 problems. And only four months have gone by.

Not knowing just what the services needed most . . .

in the way of research long has been a baffling problem to industry. Companies have largely had to depend on word of mouth to determine the long-range interests of DOD. Often the lack of proper information has sent a company down a dead end—at its own expense.

The Navy realized more than a year ago that a lot of industrial research was being misdirected and decided upon the direct approach: tell what was needed and why. It took a year of snooping around the various Navy research agencies to compile the "Research Problem" book. But the effort looks like it will pay off handsomely.

The entire book is classified, but many individual . . .

problems are not. They cover every facet of naval operations, with particular emphasis upon ASW, air defense warfare, offensive warfare and supporting research. The Navy, for example, wants someone to develop an electrically and acoustically silent battery-powered motor to cut out electrical noise that degrades electronic circuitry. This one will take a breakthrough in the present state-of-the-art.

Take missile warheads. The Navy requires a low-cost method of producing high-quality continuous rod-type warheads with a minimum number of possible variables in the manufacturing process. The method "should eliminate as many of the presently used individual parts and joints as possible by incorporating new rod forming and manufacturing techniques." The reason: aircraft target speeds and skin toughness are increasing steadily and the cutting action of continuous rod warheads is expected to become more effective than blast or fragmentation types.

On the other hand, Problem 61 in the book . . .

asks development of a more effective fragmentation warhead—"possibly by increasing the duration of the lethal fragment cloud." Present anti-aircraft bursts last but 5 milliseconds and cover an area 80 feet in diameter. Present complex arming devices for solid rocket propellants also are a problem area. The Navy wants something simpler—and more reliable.

Interestingly enough, the Navy has use for a *less* accurate gyro than those available now. It would be put in short-range missiles (for one minute or less). The idea is to come up with a gyro that is cheaper; the very precise ones in production today are too expensive to use in the short-range missiles.

The book has problems for everyone . . .

big and small companies alike. Available from BuWeap, it should be on every company shelf. For most of the solutions will lead to either research or production contracts.

Incidentally, the Army has picked up this approach from the Navy and is publishing a similar classified problem book for industry in about a year, as mentioned in this column Aug. 17. The Air Force ARDC also has a similar program going. So, henceforth, no company-funded research need go to waste.

— letters

Solid Coverage

To the Editor:

On behalf of the entire company, I take this opportunity to express our appreciation for the excellent coverage given us in Frank McGuire's review of "The Role of Solids" in the July 27th issue.

He handled a difficult and complex subject with remarkable competence and we appreciate his earnestness, caution, intelligence and courtesy . . . He will always be welcome at **Grand Central Rocket Co.** . . .

Cledo Brunetti
Vice President and
General Manager
Grand Central Rocket Co.
Redlands, Calif.

Hits the Nail

To the Editor:

You have hit the nail pretty nearly on the head in your recent editorial, "Components Reliability: What's Needed?"

The solution is by no means direct since the big men in the field are predominately either speculative scientists or "weapon system" enthusiasts, both somewhat blinded to the tedious attention to detail which is required.

R. A. Hawkins, Manager
Reliability and Quality Dept.
Avco Research and Advanced
Development Div.
Wilmington, Mass.

Pioneer Chronology

To the Editor:

I noted with interest the article by Erica Karr in your Aug. 3 issue, "BMD's Radical Approach to ICBM Pays Off."

Her list of highlights erred once.

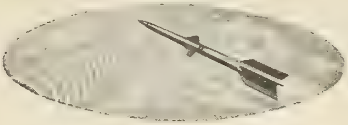
"Deepest probe into space by a man-made object was *Pioneer I's* 71,300-mile journey during which it picked up data confirming existence of the Van Allen radiation belts and confirming they would not be insurmountable obstacles for man in space, (October, 1958)."

I believe your magazine reported the flight of *Pioneer IV* in March, 1959, and the fact that it entered orbit in the solar system far beyond the range of previous U.S. space probes. I also understand that Dr. James Van Allen received highly useful radiation measurements from *Pioneers III* and *IV*, launched for NASA by the Army Ballistic Missile Agency.

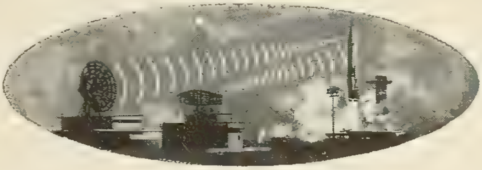
Gordon L. Harris
Public Information Officer
Headquarters, U.S. Army Ordnance
Command
Redstone Arsenal, Ala.

The article, written around the Air Force Ballistic Missile Division's fifth anniversary, did not go into space projects of other agencies. BMD's achievements were listed in order of date and Pioneer I's October 1958, journey did set a record at that time—Ed.

Interested in Systems Engineering?



There are systems



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contracts

MISCELLANEOUS

$1,600,000—Talco Engineering Co., a subsidiary of **The Gabriel Co.**, for manufacturing rocket motors, rotational and vertical thrusters and other components.

$100,000—The Siegler Corp., Olympic Division, for development of five rate and reference precision frequency generators to be used as part of the Mark II Azusa missile tracking and retrieving system for ICBM's. (Sub-contract from **Convair Division, General Dynamics Corp.**)

$60,000—DynaMetric, Inc., Pasadena, Calif., for special purpose camera equipment. (Sub-contract from **Eastman Kodak Co.**)

NAVY

$360,000—ACF Industries, Inc., Avion Division, Paramus, N.J., for production of radar beacons for use in tesing *Corvus* air-to-surface missiles.

$114,357—Mincom Division, Minnesota Mining & Mfg. Co., Los Angeles, for seven track record/reproduce magnetic recording system.

$76,175—Bendix Computer Division, Bendix Aviation Corp., Los Angeles, for a digital computer with associated components.

$25,680—Raymond Engineering Laboratory, Inc., Middletown, Conn., for magnetic tape recorder.

ARMY

$3,260,609—Pacific Construction, Ltd., Honolulu, **Reed & Martin Co.**, Fairbanks, Alaska and **H. B. Zachry, Inc.**, San Antonio, Tex., for *Nike-Zeus* facilities on Kwajalein Island in the Pacific.

$2,942,000—Westinghouse Electric Corp., Washington, D.C., for rocket and guided missile proximity fuses.

$1,858,211—Beacon Construction Company of Massachusetts, Inc., Boston, for construction of *Nike-Hercules* facilities at Offutt AFB.

$1,809,209—Beacon Construction Company of Massachusetts, Inc., Boston, for construction of *Nike-Hercules* facilities at Lincoln, Neb.

$1,676,814—Douglas Aircraft Co., Santa Monica, Calif., for missile technical services. (Two contracts.)

$590,766—Wayne Construction Co. and **Reed & Martin, Inc.**, Seattle, for construction of *Nike-Zeus* facilities on Johnston Island in the Pacific.

$539,100—Benz Construction Co., Lubbock, Tex., for construction of *Nike-Zeus* facilities at Point Mugu, Calif.

$328,939—Western Electric Co., Inc., N.Y., for *Nike* spare parts and components. (Seven contracts.)

$225,871—General Electric Co., Utica, N.Y., for satellite communications study.

$119,987—Gilfillan Brothers, Inc., Los Angeles, for engineering services for the *Corporal* missile.

$57,473—Gulton Industries, Inc., Long Branch, N.J., for accelerometers.

$40,000—Douglas Aircraft Co., Santa Monica, Calif., for guided missile supplies and services.

$37,500—Aerojet General Corp., Azusa, Calif., for activation and operation of launching equipment.

$28,939—Professional Design Co., Agawam, Mich., for engineering, design and drafting services for XM79 launcher.

$27,550—Lansdale Tube Co., Lansdale, Pa., for transistors.

AIR FORCE

International Business Machines, Federal Systems Division, Oswego, N.Y. for development of a lightweight digital computer for the achiever all-inertial guidance for the *Titan* missile. (Sub-contract from **AC Spark Plug Division, General Motors**). Amount not disclosed.

Thiokol Chemical Corp., Reaction Motors Division, has received a "significant" contract for the advanced development of mechanical features in pre-packaged liquid rocket engines. Amount not disclosed.

U.S. Steel Co., Consolidated Western Steel Division, for the fabrication of 14 *Atlas* ICBM launchers. (Sub-contract from **Convair Astronautics Division, General Dynamics Corp.**) Amount not disclosed.

The Rucker Co., Oakland, Calif., for hydraulic power systems for *Atlas* missile launching sites at Forbes AFB, Topeka, Kan. Amount not disclosed.

$36,655,000—Avco Corp., Research and Advanced Development Division, Wilmington, Mass., for basic research through prototype development of the re-entry vehicle (nose cone) for the *Minuteman* ICBM.

$29,209,851—General Electric Co., Missile and Space Vehicle Dept., Philadelphia, for production of nose cones for *Thor* missiles.

$5,000,000—Martin Co., **Orlando**, for continued research and development work on the *GAM-83B* air-to-surface guided missile.

$2,321,900—Martin Co., Baltimore, for repair and modification of *TM-61/76* missiles and related equipment.

$415,926—Telecomputing Corp., Cook Batteries Division, Denver, for production of specialized batteries to be used as electric power sources for the *Atlas* and *Minuteman* missiles. ($295,000 subcontract from **Convair Division, General Dynamics** and $120,926 subcontract from **Autonetics Division, North American Aviation, Inc.**)

$398,452—Martin Co., Baltimore, for supplies and services for maintenance of *TM-61/76* weapons systems components.

$209,100—Allen B. DuMont Laboratories, Inc., Clifton, N.Y., for various electron tubes.

$207,147—Radio Corp. of America, Harrison, N.J., for various electron tubes.

$206,630—Sylvania Electric Products, Inc., N.Y., for various electron tubes. (Three contracts.)

$170,640—General Electric Co., Owensboro, Ky., for various electron tubes.

$148,770—Sundstrand Corp., Rockford, Ill., for transmission assemblies, spare parts, maintenance tools and test equipment for *SM-62A* missiles.

$145,651—Martin Co., Baltimore, for supplies and services for maintenance of *TM-61C* weapon system components.

$44,358—Stanford University, for continued study of fluid dynamic problems in diffusers and ducts.

$42,240—The Dayton Rubber Co., Dayton, Ohio, for various tube assemblies.

$28,470—Flexonics Corp., Maywood, Ill., for various tube assemblies.

BIDS

Dayton Air Force Depot, Gentile Air Force Station, Dayton, Ohio. Att: Directorate of Procurement and Production.—Tube electron type 6N7 in a/w MIL-E-1/633 dated 4 Mar. '54 S/N 5960-188-8519—27,000 ea. RFP 33-604-60-4066Q—Bid opening 22 Sept. '59.

U.S. Army Engineer District, Los Angeles, Corps of Engineers, 751 S. Figueroa St., Los Angeles 17, Calif. Construction of radar tower and utilities at Norad Control Center (JMDC), San Pedro Hill, Los Angeles County, Calif. . . . Job . . . IFB ENG-04-353-60-11—Bid opening 29 Sept. '59.

—when and where—

SEPTEMBER

New York University's College of Engineering, Titanium Metallurgy Conference. For Information: Dr. Harold Margolin, New York University, University Heights, New York, Sept. 14-15.

Society of Automotive Engineering, Display of USAF Ground Support Equipment for Manned and Unmanned Aerospace Vehicles, Milwaukee Arena, Milwaukee, Sept. 14-15.

Institute of the Aeronautical Sciences, Western Regional Meeting on Frontiers on Science and Engineering, Los Angeles, Sept. 16-17.

Army Signal Corp., Conference on Effects of Nuclear Radiation Semi-conductors, Western Union Auditorium, New York, Sept. 17-18.

Standards Engineering Society, 8th Annual Meeting, Investment in Survival, Somerset Hotel, Boston, Sept. 21-22.

Instrument Society of America, 14th Annual Conference and Exhibit, International Amphitheatre, Chicago, Sept. 21-22.

Industrial Nuclear Technology Conference, sponsored by Armour Research Foundation of Illinois Institute of Technology, Nucleonics Magazine, and Atomic Energy Commission, Morrison Hotel, Chicago, Sept. 22-24.

Advisory Group for Aeronautical Research and Developments (AGARD) of the North Atlantic Treaty Organization, Aachen, Germany, Sept. 24-25.

Institute of Radio Engineers, American Institute of Electrical Engineers, 8th Annual Industrial Electronics Symposium, Mellon Institute, Pittsburgh, Sept. 30-Oct. 1.

OCTOBER

Institute of the Aeronautical Sciences, Anglo-American Aeronautical Conference, Hotel Astor, New York, Oct. 5-7.

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The Warm Side of the Cold War

The visit to this country of Nikita Khrushchev is significant in several ways. Historically, he is the first Russian chief of government to set foot on American soil. Historically, also, he arrives near the second anniversary of his nation's greatest technological triumph—the orbiting of *Sputnik I*. Politically, he is linked to the Administration's hopes of cutting down the military budget. Morally, he holds the hope of the West for a lessening of tensions, for disarmament, for global sanity.

It is very difficult to believe that the Soviet Premier will really change any of his communistic spots during his visit here, or immediately thereafter. However, we do believe it is far better for East-West protagonists to meet personally on almost any terms than to stand glowering at each other across the oceans and continents. And there is always the hope that the visit will enlarge the Premier's outlook.

With this in mind we would like to call his attention to the lead story in this issue of this magazine—a story dealing with the peaceful uses which American industry has found for products and techniques developed during the Cold War of the past decade.

Khrushchev's contempt for capitalism is well and widely known. Alluding to America on Oct. 10, 1957, he said: "There are still reactionary militarist forces in the world which are preparing for war and which do not want disarmament, fearing to lose their profits. The capitalists are worried about their profits."

It would be strange indeed if capitalists were not concerned to some extent about their profits, profits being one of the prime bases of capitalism. But it might surprise the Soviet Premier to learn the trend this concern takes.

As detailed in this week's story, an M/R survey revealed that during the past decade military, missile and space research has produced countless new products, new industrial techniques and even entire new industries for peaceful, civilian usage. While working to produce better defense vehicles and spacecraft, American industry has never lost sight of the fact that it is inherent in its very nature to be always searching for ways to improve the everyday living of the American people. Missile optics produce better eyeglasses; the material created for a radome also makes more durable kitchenware; the search for a new fuel produces a new medicine and thus on.

No democratic society has ever looked favorably on military expenditures. The attitude has always been, understandably, that military spending is almost literally waste, that a dollar for defense could be spent for some worthwhile purpose if defense weren't necessary.

Within our military budget, which accounts for from 10 to 15% of our gross national income, many items have been produced which have great economic (as well as military) value. They have lessened man's labors, improved his health and well-being, lengthened his life span. This is not and never will be an argument for increasing military budgets, of course; but it does demonstrate that these military expenditures have brought civilian benefits which otherwise might not have resulted—or at least would have been years longer in arriving.

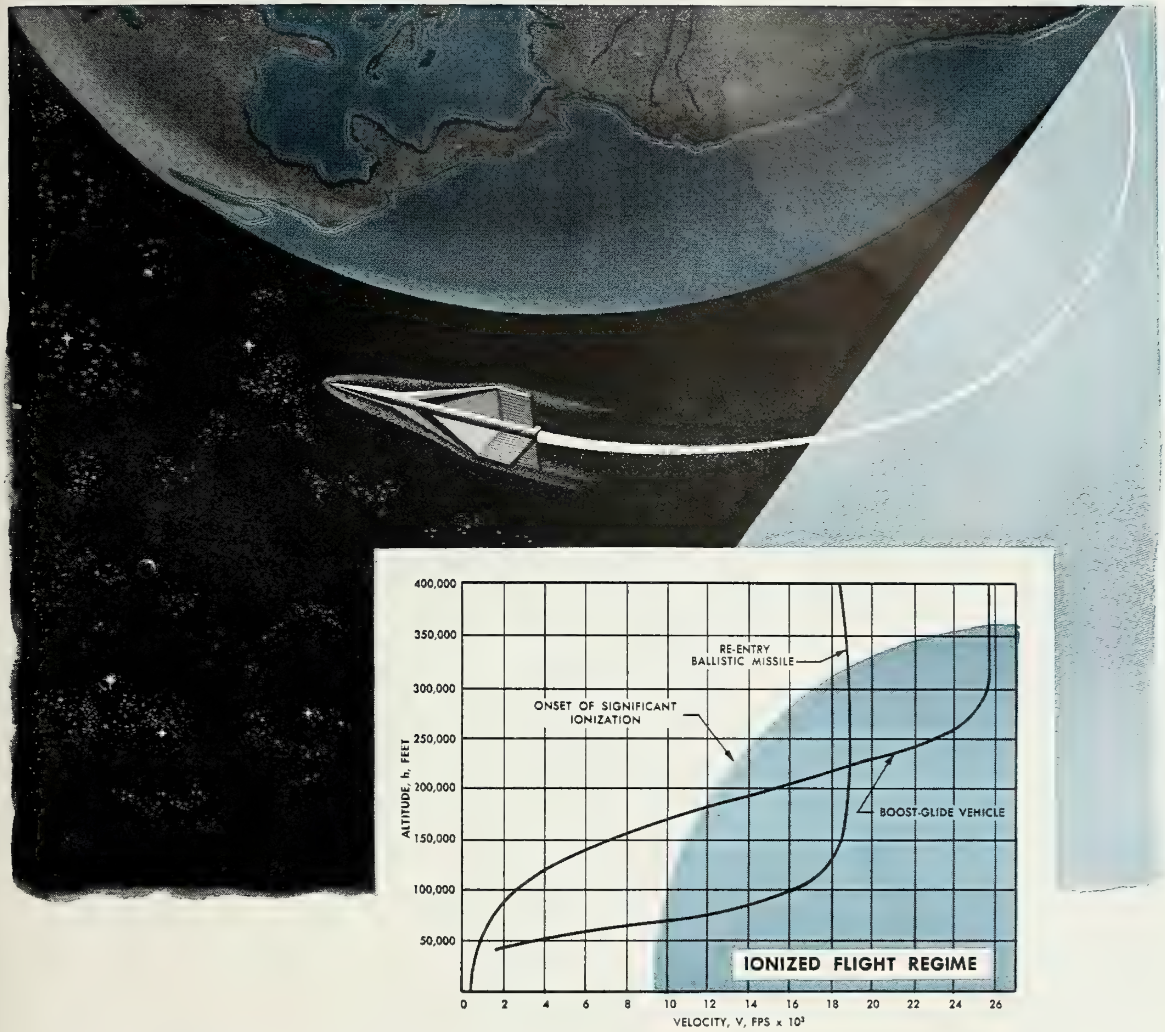
The point which we hope will not be permitted to escape the attention of Premier Khrushchev is this:

> **Not only can this country devote its economy to building one of the greatest defense machines in the world, aid its western allies both militarily and economically, create and carry out a potentially great space program—it can do this and at the same time give its citizens the highest living standard ever known.**
>
> **Not only has this country accepted the challenge of the Cold War which the Russians have forced upon us, but in effect we are making it pay for itself through our vast production system and consumer capacity.**

We think this is a tribute to the American system and to American industry. We doubt that the same thing is even remotely true in Mr. Khrushchev's country; his own technical leadership isn't geared to think of civilian well-being, either industrially or spiritually.

If this one fact can be brought home to the Soviet Premier it may both enlighten and discourage him somewhat—enlighten him to the fact that though we don't try to force our way of life on the world, we like it; and discourage his hopes of changing that fact.

CLARKE NEWLON



COMMUNICATION

...through a plasma sheath

When man goes into the outer atmosphere, communication with ground installations will be a major problem. The shock wave preceding a hypervelocity vehicle flying at altitudes between 70,000 and 350,000 feet will cause the oncoming air to be heated to extremely high temperatures. Result: a sheath of ionized particles around the vehicle.

Communication through this plasma cannot be achieved with conventional equipment. That's why Bendix Systems Division is engineering a communications system in frequency bands specifically designed to penetrate the hypersonic shock layer. The solutions of these problems are common to hypersonic flight and ballistic missile re-entry.

The Bendix Systems Division, using the nearby University of Michigan's Ford Nuclear Reactor, is also developing radiation-resistant communication equipment to provide extreme reliability over long operating periods. These techniques are applicable to both nuclear-powered vehicles and space programs.

Bendix communications experience is also being applied to other programs for which the Systems Division has management and engineering responsibility—the Navy's EAGLE System and the Air Force's AN/AMQ-15 Weather Reconnaissance System, for example.

Better engineers and scientists are invited to write for further information on Bendix Systems Division.

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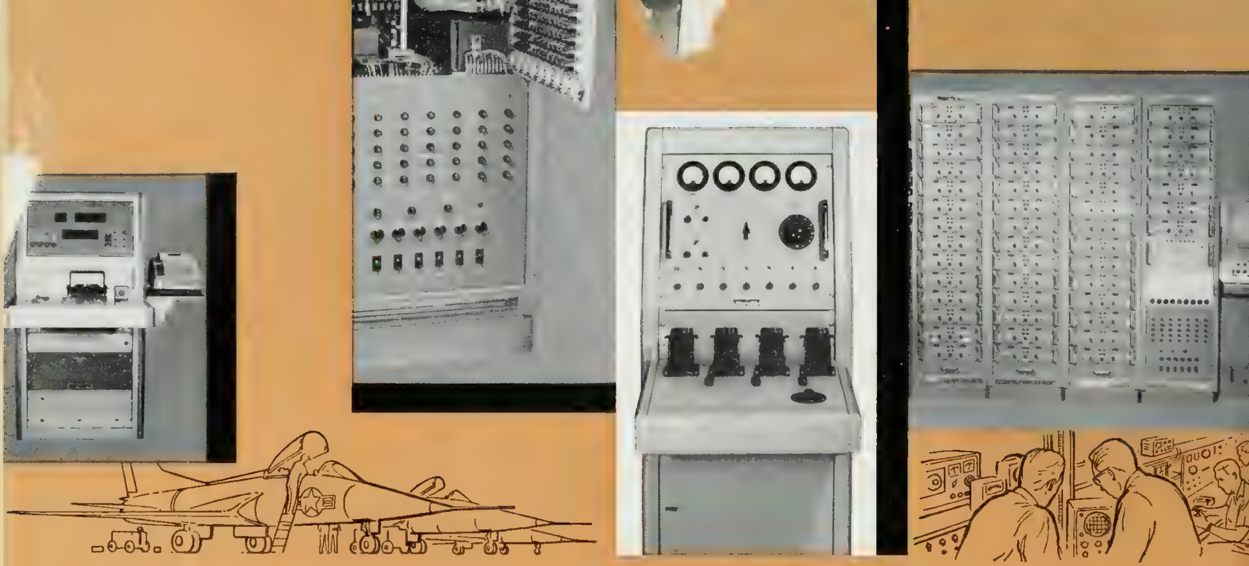

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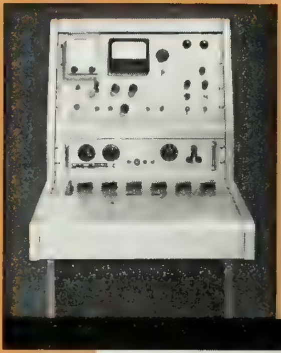

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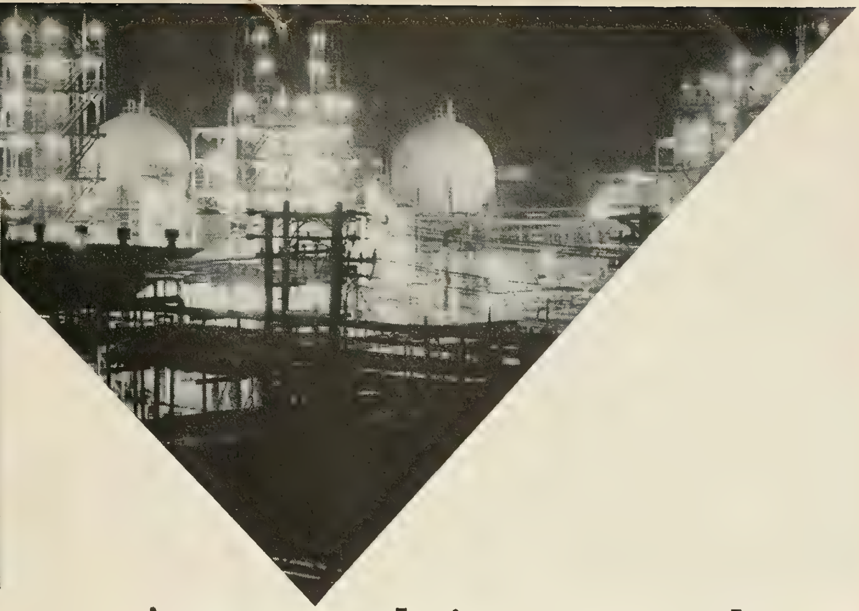

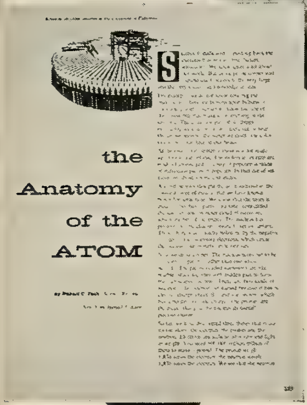

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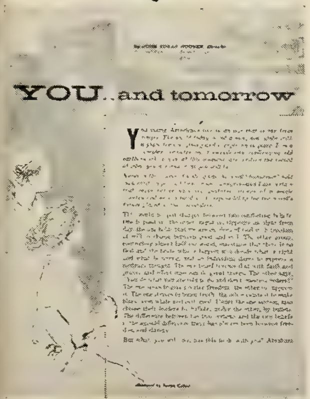

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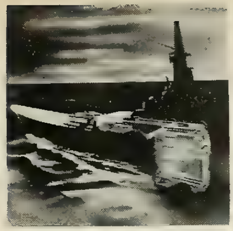
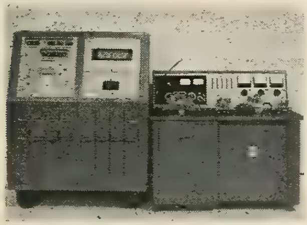


COVER: seaborne support for *Talos* is shown in previously unpublished picture by GE artist. For story on the Navy's triple-threat missile, see p. 24. For story on GE's *Talos* hoist, p. 26.

READY for installation at *Atlas* ICBM bases are plastic-wrapped 1600 KW transformers, symbolizing massive missile support needs. A summary of the huge market starts on p. 21.



COMPLETELY solid-state and modularly constructed is Stromberg-Carlson's SCATE, a typical advanced automatic checkout system. A survey of this rapidly growing market starts on p. 53.

BMEWS prototype installation recently completed near New Jersey Turnpike. Two BMEWS sites have been established in Alaska and Greenland. Turn to the report beginning on p. 67.

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Potential market is nearly one-half billion dollars. By George A. Peck, vice president, Stromberg-Carlson 53

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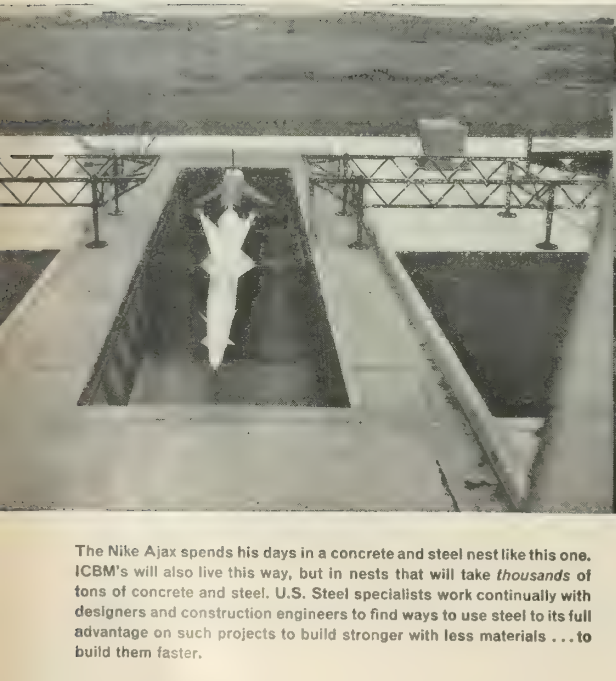
About the earthly side of the Nike Ajax.

The U. S. Army's Nike Ajax is a strange but potent bird. Graceful, tough, packed with delicate instruments. He will fly only once in his lifetime—only in the event of an enemy attack. To launch him with split-second timing and accuracy, the Army puts most of its manpower and most of its materials into ground equipment. And virtually all the material required other than electronic equipment can be purchased from one firm—United States Steel. Whether you're talking about carbon steel, high-strength low-alloy, or ultra high-strength alloy steels, Stainless Steel, steel fence,



The Nike Ajax spends his days in a concrete and steel nest like this one. ICBM's will also live this way, but in nests that will take *thousands* of tons of concrete and steel. U.S. Steel specialists work continually with designers and construction engineers to find ways to use steel to its full advantage on such projects to build stronger with less materials . . . to build them faster.

It takes miles of wire and cable to rig a Nike nest. It will take *hundreds* of miles when bigger birds are put to roost. The Army uses many types of steel and steel products in a Nike nest. U.S. Steel conducts research and knows how to cut costs for any steel product used in ground support equipment.

electrical cable, cement or wire rope, United States Steel maintains the technical services to provide the proper assistance to cope with any problem on materials for ground equipment. When a ground support program goes to the drawing board, consult with

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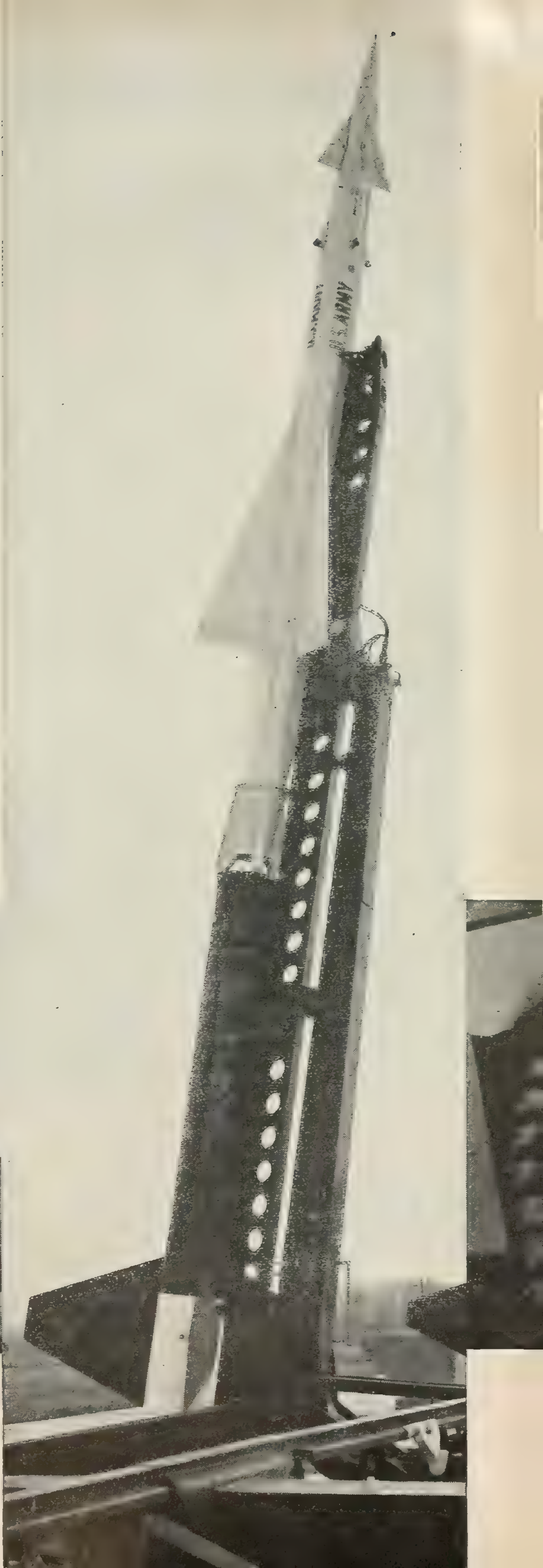

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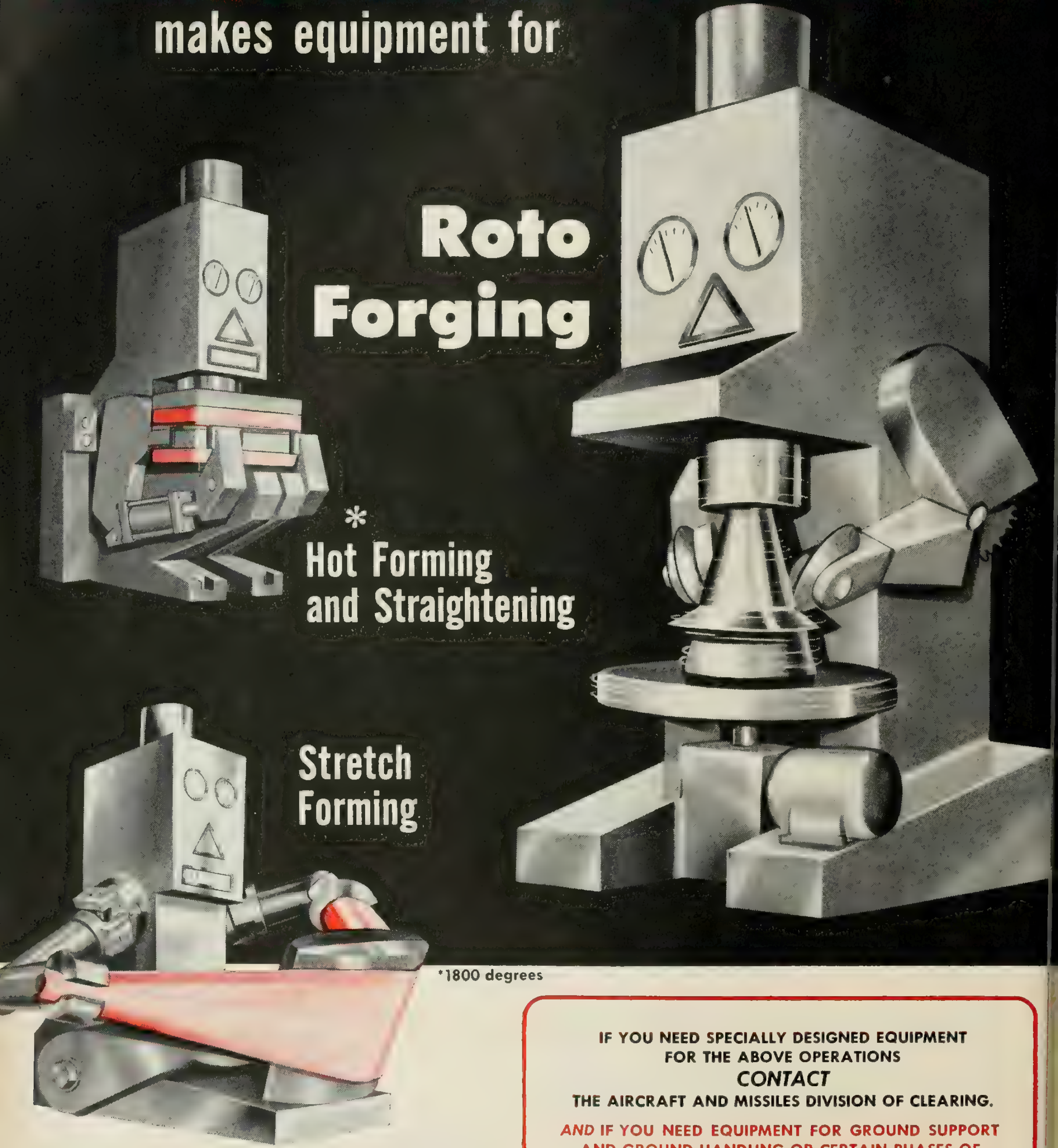
makes equipment for



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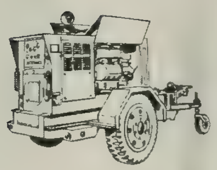
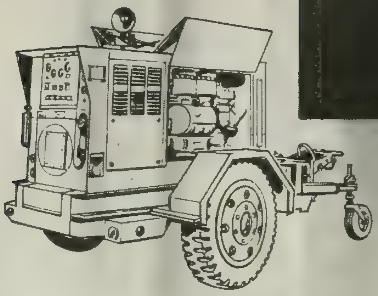
before you leave and after you get there . . .





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Washington Countdown

IN THE PENTAGON

The first experimental *Samos* . . .

the ARPA-Air Force reconnaissance satellite, is expected to be launched about next March. The R&D satellite will be placed in a polar orbit—enabling its camera at one time or another to see all points on the earth.

• • •

The first operational *Transit* . . .

the ARPA-Navy navigational satellite, is expected to be in orbit no later than early 1962. However, a virtually operational *Transit* satellite may be in orbit by the end of next year.

• • •

Doubling the warhead . . .

of the **Boeing** *Minuteman* and **Lockheed** *Polaris* appears possible if ARPA's project to boost the performance of solid propellants about 20% is successful. Both missiles pack about a one-megaton warhead. Some scientists think ultrafine aluminum powder may be a good bet.

• • •

A catchy name . . .

is being sought by the Air Force for its air-launched ballistic missile. The **Douglas** missile is known popularly by the initials ALBM. But the Air Force apparently wants something snappier.

• • •

An Hawaiian base . . .

on the big island of Hawaii for launching and tracking polar-orbit satellites is reported to be under consideration. **The Ralph M. Parsons Co.** has submitted a proposal for the base with a $38.8-million price tag.

• • •

Testing of *Bullpup* . . .

for compatibility with Air Force jets is being conducted. However, the Air Force is expected soon to begin ordering the Navy-air-to-ground missile with few changes for operational deployment.

• • •

Manned Moon flights . . .

from the United States probably will be made from orbiting space platforms rather than Earth unless current Pentagon planning is changed. The whole question is before ARPA scientists for study and early decision under Project *Suzano*.

ON CAPITOL HILL

Congressmen aren't forgetting . . .

the tremendous success of *Lunik II*. Only the pell-mell rush to get out of town before Soviet Premier Khrushchev arrived staved off a congressional investigation of why Russia beat the United States in planting a flag on the moon. An investigation is almost certain to be held later this fall or next January at the latest.

• • •

L'affaire Power . . .

is bubbling along. The Pentagon has told the House Information Subcommittee that it banned SAC Commander Power's book about U.S. missile and bomber forces because it was against Defense Department policy for him to write it—not because of what he wrote. The Subcommittee's next question: Since when?

AT NASA

A big cut . . .

has been decided on in the worldwide tracking network planned for Project *Mercury*. The reason: Lack of money. Originally NASA planned to build 14 bases costing a total of more than $15 million.

• • •

Fifty-million miles . . .

is the distance NASA scientists hope signals from *Thor Able III's* solar cells will carry. NASA plans to launch the *Able III* satellite into orbit around the sun late this fall. If accurate enough data is received about its orbit, scientists will be able to track it every time its orbit brings it between the earth and the sun.

AROUND TOWN

One of the big fights . . .

of the British elections will be over U.S. *Thors* in Britain. The Laborites will charge the **Douglas** liquid IRBM's don't have the needed fast reaction time—under 15 minutes.

• • •

Some of the reports . . .

being passed as "the latest" in the nation's capital:

. . . Russia may try during Premier Krushchev's visit to top *Lunik II* with an up-and-down flight by a manned missile.

. . . Pressure for East-West space projects is expected to grow.

. . . The first French A-bomb test is imminent and nuclear-tipped missiles will follow swiftly.

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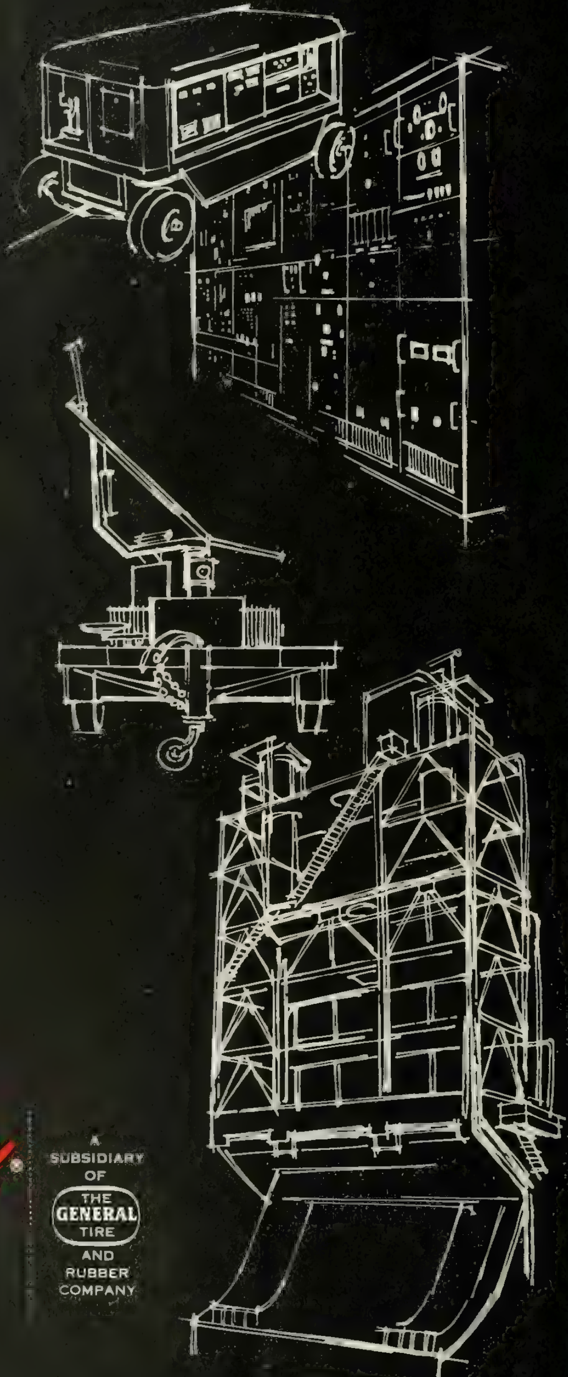


Industry Countdown

MANUFACTURING

'Plug-in' payloads . . .
standardized at 270 pounds and the same configuration will be inaugurated soon by ARPA in many U.S. space vehicle programs. Modifications of the workhorse *Thor-Able* three-stage missile will be used for the first packaged systems. The method is aimed at saving time and money and considerably simplifying both design and launching operations.

• • •

Satellite re-entry system . . .
which will deliver a large number of relatively small packets back to earth on command has been devised by **Hughes Aircraft.** One application of the system would be to drop weather-reporting radio transmitters in remote areas.

• • •

***Minuteman* mobility battle . . .**
being waged behind the scenes at the Pentagon is one to watch. It will be a key future item in the missile support market (see p. 21). The controversy is over 1) the percentage of the programmed 2600 *Minuteman* missiles to be made mobile, and 2) whether they will be on rails, wheels or waterborne. One factor weighing against mobility is that the solid-fueled ICBM will be as fragile as a clutch of grouse eggs, and very tricky to handle. Latest word from the Air Force is that a "sizeable" portion will be mobile.

• • •

Ultrapure silicon . . .
metal production plant will be sought by Air Force next year. On full stream, impurities must be held to one part in six billion—a tough requirement.

PROPULSION

French are making significant . . .
strides in solid-propellant castings. Service des Pondres government agency at its St. Medard facility near Bordeaux has successfully fired several grains of 1000 pounds weight and is actively researching aluminized powder injections. The agency also has developed a polyvinyl chloride material for ammonium perchlorate.

• • •

Vernier guidance . . .
for extended space probes is a possible mission of **Republic Aviation's** plasma jet engine. Development of a lightweight, high-yield electric power source to run it, however, still remains one of the most critical unsolved spaceflight problems.

Container structure . . .
including rocket assembly with casing, gas producer and igniter for separate storage of liquid propellants has been patented by the Navy.

• • •

Ultrafine aluminum powder . . .
in 300-to-400 micron range will be developed for Navy by **National Research Corp.** under $100,000 contract. It will be followed by a contract to develop similarly fine powder aluminum alloys with other materials—zirconium, magnesium lithium, etc.—for rocket propellant use. This is the new technology which put boron out of business.

ASTRIONICS

All of Prof. Fred Singer's . . .
calculated principal characteristics about the Van Allen radiation belts have been supported by subsequent satellite and space probes.

• • •

***Explorer VI* 'telebit' . . .**
telemetry has provided enough data to indicate a much longer concentration of low-energy particles in the Van Allen belts than previously postulated—about 200 kev, according to Dr. G. E. Mueller of **Space Technology Laboratories.**

• • •

A joint report . . .
by Holly, AF Special Weapons Center, and Johnson of **Lockheed,** indicates composition of radiation at altitudes up to 1000 km. Radiation penetrating 30 mg/cm^2 is predominantly electrons. The data still supports earth neutron-albedo theory.

WE HEAR THAT—

Gold plating for missiles . . .
is still considered by metallurgists and missile engineers as having no equal as a protective against re-entry heat (except for nose cones) . . . **General Dynamics** is another firm taking an interest in controlling solid-fuel burning with sound in the 150 decibel region . . . More structural applications is the goal of a beryllium extruding process being developed by **Northrop** and **Beryllium Corp.** . . . Research on explosive forming of zirconium will be started by Interior Department's Bureau of Mines this year and will be followed by work on deep drawing and extrusion . . .

More About the Missile Week on Page 107

GROUND SUPPORT EQUIPMENT

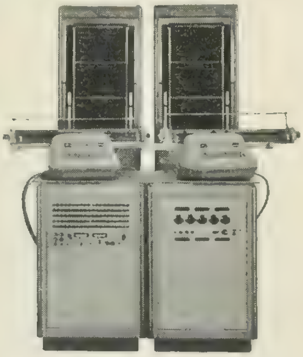
A Proven Kearfott Capability – Kearfott's prominence in the design and production of ground support equipment is a result of 15 years' experience in producing precision servo systems, computers, gyro reference systems and inertial guidance equipment. Kearfott test equipment is designed on modular principles which increase flexibility and economy and eliminate the obsolescence factor since modules can be readily modified or replaced. Modules are designed to be compatible with one another, thus providing test capabilities for a wide variety of applications.

Inertial Guidance System Test Console

IN-PLANT TEST EQUIPMENT: Rack-mounted modules comprise the necessary metering circuits, signal generators and power supplies, switching circuits and junction boxes to perform the following tests on inertial reference systems:
Voltage and phase • Current • Heating cycle checks • Verticality of platform in ground erection mode • First order erection time in ground erection mode • Measurements of platform roll and pitch output angles in ground erection mode • Measurements of free drift of platform in azimuth in ground erection mode • Measurement of azimuth gyro torquer scale factor in ground erection mode

FIELD-TYPE TEST EQUIPMENT: Modularized, self-contained unit that provides all power and signal voltages to operate, test or trouble-shoot a gyro. All inputs to and outputs from the gyro are accessible at convenient jacks where connections to measuring equipment can be made, thereby enabling operator to evaluate gyro performance completely. Modules are slide-mounted for ready access if repair, modification or product improvement replacement are required. This portable equipment performs these basic tests:
Insulation resistance • Warm-up time • Torquer scale factor measurement Gyro transfer function • Free drift • Gimbal offset drift • Continuity Signal Generator Null • Phasing • Gyro drift • Fixed torque restraint

Floated Gyro Test Console

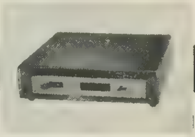

Scanalog 200-Scan
Alarm Logging System

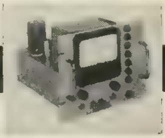
GENERAL PURPOSE DATA PROCESSING: This data handling system provides a reliable, precise means of monitoring, logging and performing an alarm function of up to 200 separate temperature, pressure, liquid level or flow transmitters. Manual controls are provided for scanning rates, automatic or manual logging, data input relating to operator, time, day, run number and type of run. 200 numbered lights, corresponding to specific points being maintained, provide a visual "off normal" display for operator's warning. This system has growth built in and can be expanded in capacity to 1024 points and in scanning rate to 2000 points per second.

Write for complete information on Kearfott's ground support equipment.

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

VTVM-PSVM


High-Speed
Precise Angle
Indicator Module


Automatic
Ohmmeter
Module

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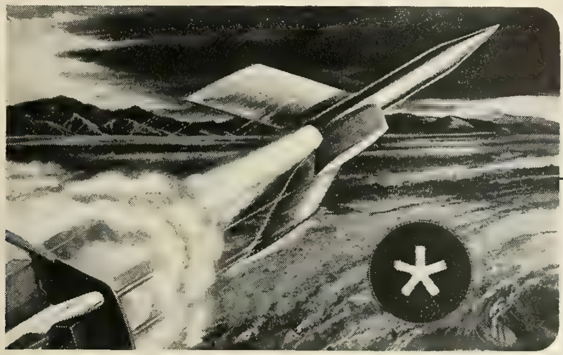
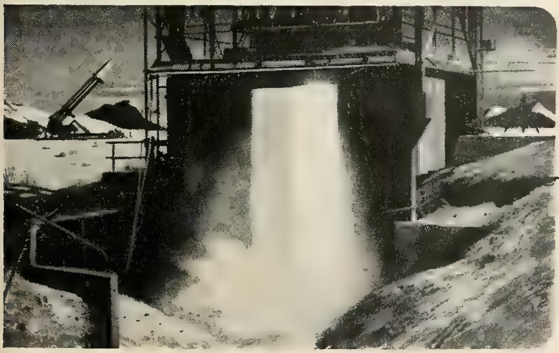
Pioneering Achievements in Rocketry at JPL

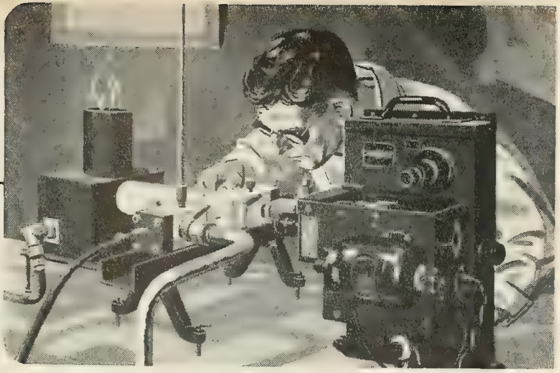
LIQUID PROPELLANT SYSTEMS...were pioneered at JPL. Development work began in 1943 and led to the first practical rocket power-plant in the United States in which spontaneous ignition took place upon mixing of the oxidizer and fuel.



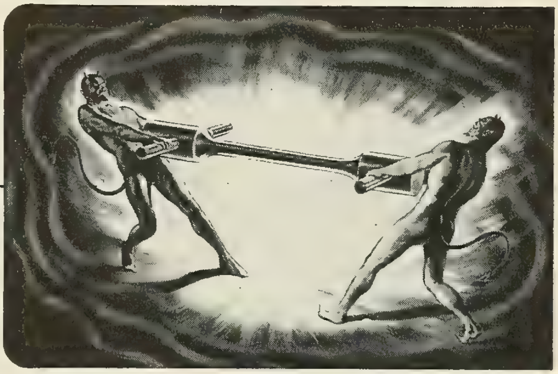
SOLID PROPELLANT SYSTEMS...received momentous impetus in 1947 with the successful flight of the Thunderbird, a test rocket. This JPL pioneering achievement demonstrated a new technique which has since revolutionized the field of solid propellant rockets.



DEVELOPMENT . . . of efficient rocket power plants involves large scale testing and the application of knowledge from many scientific and engineering fields—thermodynamics, combustion, heat transfer, fluid mechanics, and metallurgy.



HEAT TRANSFER . . . studies at JPL with a camera using a Kerr cell shutter taking photos at 20,000 frames per second were the first high-speed, high-resolution motion pictures successfully recording the action of nucleate boiling.



MATERIALS RESEARCH AND TESTING . . . is one of many supporting research programs under way at the Laboratory and are considered a "must", in providing needed data for engineers concerned with the design and development of propulsion systems.

TESTING . . . of rocket engines resulted in the establishment of a center for recording rocket engine measurements when in 1948 the Lab established the first system serving five engine test cells. This has now expanded to a complex multi-channel system.

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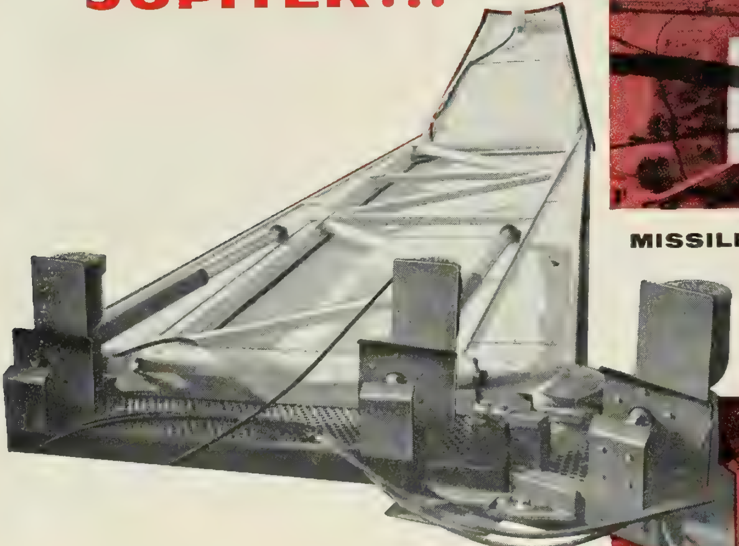
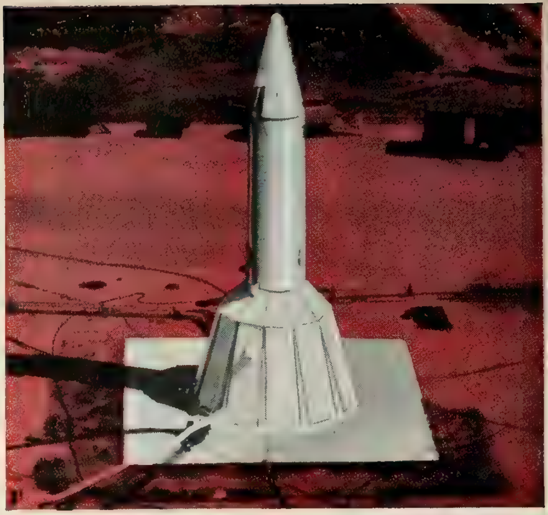
HURRICANE-PROOF "OVERCOAT" FOR THE JUPITER...





MISSILE SHELTER-PANELS RAISED

MISSILE SHELTER-PANELS OPEN

"buttoned up" by 24 Saginaw b/b Screws

Buttoning up the "overcoat" for the Jupiter IRBM is a cinch for the Saginaw Ball Bearing Screw! The "overcoat" is a portable prefab standby shelter designed by Barnes & Reinecke, Chicago, and U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., to protect the missile's tail and personnel working on it. The shelter has 12 base sections with hinged panels raised electrically to form a weather-tight seal around the Jupiter's hull.

The Saginaw b/b Screw converts *rotary* motion into *linear* with over 90% efficiency. This enables the Saginaw Screws to dependably raise or lower these panels—and hold the shelter securely in place—even in the face of 76 mph hurricane winds. In fact, each Saginaw Screw is able to withstand a combined wind and weight stress of almost five tons! The Saginaw Screw also offers substantial savings in space, power and weight which make the shelter easier to transport and assemble.

The Saginaw Screw may be able to give *your* products that valuable Sales Appeal you're looking for. To find out, write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*

Give your products
NEW SALES APPEAL...
switch to the

Saginaw

ball/bearing Screw

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You can turn your toughest GSE problems over to **Hamilton Standard** division of **United Aircraft Corporation**

Hamilton Standard has expanded its Ground Support Equipment Department, making available to the entire aircraft and missile industry its skilled personnel, technical "know-how" and complete, modern facilities. Hamilton Standard has capabilities for solving virtually all GSE problems—from initial design concept through production and system management, from tools and equipment to fixed facilities.

More than 40 years experience and a highly competent organization with unusual skills and facilities—backed by the services and resources of United Aircraft Corporation—provide first-line qualifications and capabilities in the GSE field. For further information contact:

GROUND SUPPORT
EQUIPMENT DEPARTMENT

HAMILTON STANDARD
A DIVISION OF UNITED AIRCRAFT CORPORATION
Windsor Locks, Connecticut

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PINCH PLASMA ENGINE
NEW POWER FOR SPACE VEHICLES

"The experimental model of a new concept . . . a magnetic pinch plasma engine for interplanetary space trav is in operation at our laboratories," says Alfred Kunen (R) Project Engineer, Plasma Propulsion Project, shown wit Milton Minneman of Republic's Scientific Research Staff, during actual operation of the engine. ➤➤➤ Republic's plasma engine unique in that it utilizes intermingled positively and negatively charged particles in a single jet thrust, can operate on fuels more readily available than required for an ion engine, and attains greater thrust. By compressing these particles in an invisible cylindrical magnetic girdle and shooting plasma out the rear at tremendous velocities, sufficient thrust is generated to push a vehicle through the near-vacuum of outer space. ➤➤➤ Republic is working on advanced plasma engine studies for the U. S. Navy Office of Naval Research and the U. S. Air Force Office of Scientific Research. ➤➤➤ **Today's pinch plasma engine is but one of many bold concepts under development at Republic to create for the space world of tomorrow. It is part of Republic's multi-million dollar exploration into the realm of advanced aircraft, missiles and space travel.**

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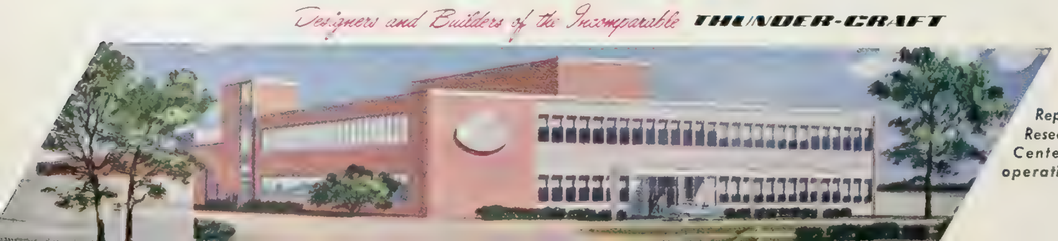


Republic's new $14,000,000. Research and Development Center, is scheduled for operation early in 1960.

Missile Support—$40 Billion by '67

Hardened ICBM bases and Polaris submarines are setting the pace for an expanding market— A complete forecast for the vital years 1960-61

by William E. Howard

WASHINGTON—Today's huge ICBM base construction program and the Navy's big switchover to missiles are pushing the already booming missile support industry into a new era of expansion.

Throughout the Defense Department more than $3 billion will be spent in FY 1960 on the bases, ships, machinery, communications, fueling, guidance and fire control systems to back up the Nation's vast missile program. Next year, as more and more missiles become operational, the amount promises to rise substantially.

Over the next seven years—barring a drastic change in the arms race with Russia—a projection by the M/R Research Department shows a support market potential topping $40 billion.

Dominating the outlook for the support field—indeed the whole missile industry—is the swift buildup of ICBM bases and the nuclear-submarine launched *Polaris* IRBM. With the deployment of the first operational *Atlas* ICBM's at Vandenberg AFB, the entire ICBM effort is now moving into high gear.

How many ICBM's will the United States build? The actual number is a closely held DOD secret. But it is extremely likely base construction will accelerate over the next five years.

Today, the Air Force is constructing 11 (7 *Atlas*, 4 *Titan*) installations and in the next few months is expected to announce nine additional ICBM sites. The FY 1960 construction budget contains $550 million for ICBM bases—most of them "hardened" (underground) to withstand a nuclear attack.

Fully 80% of the $100 million total cost of one hard ICBM base is in the ground environment.

- *Titan* **cost breakdown**—Each ICBM base now is costing between $40 million and $45 million just to build—digging the silos or emplacements for 10 missiles (including one spare) and putting down the reinforced concrete for the entire facility.

Missile Support Equipment Procurement

(millions of dollars)

	1960 (Estimated)	1961 (projected)
Air Force	$ 642.5	$ 810
Army	421	440
Navy	1,029*	1,200*

*Includes Polaris submarines and missile surface ships

Total equipment cost for one *Titan* squadron is an additional $47.3 million. Here's the breakdown: launchers—$19 million; guidance systems—$14 million; fueling systems—$9 million; automatic checkout—$4 million; communications and fire control—$1 million; and transportation and handling equipment—$350,000.

Some of the $550 million in construction money probably will be used to start the first *Minuteman* bases next year. DOD plans call for production of about 2600 of the second generation solid-fueled **Boeing** *Minuteman.* The great majority of them will be emplaced in "hard" silos in widely dispersed squadrons of 20 to 30 missiles. The remainder will be put aboard mobile launchers.

Missile Base Construction

(millions of dollars)

	1960 (Estimated)	1961 (projected)
Air Force (ICBM)	$550	$630
Air Force (other) .	117	100
Army (Zeus)	58	?
Army (other)	90	100

Many variables—a shift in emphasis on strategic weapons or a change in the Cold War—could affect the ICBM base program. However, it is apparent that DOD presently is pursuing a course which could mean a total of 25 to 50 ICBM installations by 1965 and a support market of $2 billion to $4 billion from this source alone.

- **Bigger electronic demand**—A lion's share of the missile support equipment market—20% this year and expected to double by 1965—is going into electronics. Missile base guidance systems comprise a considerable part of the rising demand, and the largely remotely-controlled *Minuteman* will require an even greater percentage than *Atlas* and *Titan.*

Programs which will increase electronic output in the years ahead also include:

- SAGE and BMEWS and the entire global communications network giving the nation warning of an oncoming attack and the means to send retaliatory planes and missiles into action. In FY 1960 about $800 million will be spent on these systems by the Air Force—and the great proportion of it in giant radar dishes, computers, etc.
- Communications, navigation and fire control systems for *Polaris* and the surface-ship family of Navy *Tartar, Terrier* and *Talos* missiles.
- Missile ranges. More than $30 million is programmed for the Pacific Missile Range in FY '60 and before it is completed several years hence, the Navy expects to spend $256 million. About $44 million is being earmarked by the Army for an electronic equipment testing range at Fort Huachuca, Ariz., where it plans ultimately to spend a total of $107 million. It also is planning multi-million dollar improvements in the instrumentation of

← Circle No. 34 on Subscriber Service Card.

bigger slice for electronics?

the White Sands Missile Range.

• ***Zeus* question**—One of the major decisions now confronting Pentagon experts in making up the 1961 budget is the Army's *Nike-Zeus* anti-missile missile. To achieve operational capability by 1963—and to have the bases from which to fire the big AICBM, it is estimated DOD will have to program $1.5 billion to $2 billion for *Zeus* next year.

The system for detecting oncoming missiles and intercepting them will be largely on the ground.

Ultimately, if *Zeus* gets a go-ahead (and strong arguments are being brought against the wisdom of the system) it could cost $5 billion to $10 billion—with about 80% of this amount going into ground environment.

Zeus points up an interesting trend that is already being advanced by the Navy in *Talos*, *Terrier* and *Tartar* missiles. That is: to make the birds "dumb" as possible.

"Most missiles right now are too smart," says a Navy R&D official. "Too much of what we consider to be non-expendable equipment—the expensive guidance system—is in the missile. We want to make the missile itself stupider and keep most of the guidance system on board ship. This will mean building bigger computers—but I think it will save money in the long run."

There is a chance this trend may catch on in the larger missiles, providing a bigger slice of MSE for electronics.

• **Mobility**—Much is being said these days about ICBM mobility, but little is being done in the way of funding. M/R has learned that a proposal to put the solid-fueled *Minuteman* on rails camouflaged in freight trains has been shelved—at least temporarily.

The latest idea is to mount them on special overland truck-trailers, and move them about unpopulated Federal lands in the far west. Trains are considered vulnerable to nuclear blast ground shock. They also would invite random missile strikes at cities in a big war.

Best bet is that mobility will be left largely to the Navy, both in *Polaris* subs and with surface ships outfitted with *Polaris* and other long-range missiles. The Air Force also is developing an air-launched ballistic missile to fill the mobile requirement in the weapons "mix."

The ALBM system when perfected probably will have a capability of computing all necessary targeting data aboard its carrier plane—creating a demand for more and more electronic miniaturization.

Including the cost of submarines and shipbuilding, the Navy potentially is as big—or bigger—a missile support market than the Air Force.

More than $2.3 billion already has been funded in the *Polaris* program. This includes money for five FBM submarines under various stages of construction as well as R&D for the missile. In the FY '60 budget $196 million has been appropriated for four more FBM subs.

This could be just the beginning—particularly if the Navy prevails in the "mobility" role. Naval officials are talking in terms of 40 to 50 FBM subs. The chances are good they will get 25 or 30. With the nuclear-powered subs costing $100 million apiece equipped, exclusive of missiles, this would be a substantial program.

Each FBM sub carries 16 missiles costing about $500,000 each off the production line. Price tag for a combat sub: $108 million.

The cost of converting moth-balled battleships and cruisers to *Polaris* launching platforms could run into the hundreds of millions.

The Navy also is building (at $100 million per copy) one *Talos* guided missile cruiser and has plans for two more. Appropriations in FY 1960 call for building three guided missile frigates—$180 million; three guided missile destroyers—$103 million; and converting one cruiser to a *Talos* launcher—$107.5 million.

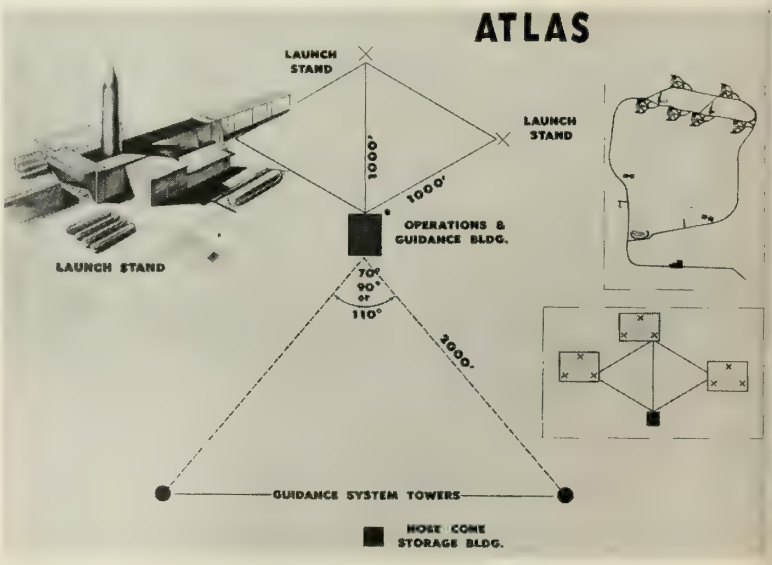
What the Navy is allowed in the way of shipbuilding funds, says one high Navy official, is "directly related to our missile capability." When funds are cut, the cut is taken out of the missile—not the ship. If a ship is started this year, and some time before it is completed there is a cutback, the ship will be completed—but its missile armament will be reduced accordingly.

The Navy does not make any budget breakdown of its direct missile support requirements. But officials estimate that for every $100,000 "that flies," there is $10 million worth of seaborne equipment backing it up.

• **Non-ballistic bases**—The FY 1960 military construction bill has dealt a blow to both the *Bomarc* and *Mace* programs. Congress wants most of the pending *Bomarc* construction held up until DOD determines whether the anti-aircraft missile bases should be located further north, perhaps in Canada or Alaska. Funds were deleted for hardening the Tactical Air Command *Mace* in overseas bases.

Mace is now a completely mobile weapon and considered vulnerable. The charge for MSE, test and checkout equipment for a *Mace* group consisting of 40 missiles comes to $17.5 million.

• **Market trends**—DOD in FY '60 has earmarked a total of about $5.9 billion for missiles. This amount contains a hefty 30% for R&D of the birds as well as their support equipment.



FIRST *ATLAS* sites are above ground. Seven *Atlas* bases are being built, with the three launchers at Vandenberg AFB the first to become operational. BMD has $550 million in ICBM construction funds in FY '60—may soon announce 9 more sites.

Actual spending on support equipment for operational missiles including ship procurement will run to about $2.1 billion. The base construction bill totals $815 million. BMEWS, SAGE, missile ranges and test facilities will send the total support bill well over $3 billion.

Through 1962, missile expenditures are expected to increase at the rate of about $1 billion a year. With the trend now definitely setting in for more and more missiles to become operational, the support requirements will increase, with a proportionately larger share of the missile dollar.

Expect the support market to get more competitive. Further modifications of the U.S. missile program are inevitable next year as a result of the Eisenhower Administration's decision to freeze the DOD budget at the current $40 billion-or-less ceiling. This limitation is forcing some hard decisions—among them *Nike-Zeus*—to be made now by defense planners drawing the FY '61 budget, which will be presented to Congress in January.

SAC's big bomber program may be a prime target for cutbacks. But so will many marginal missile programs.

Budget planners will find some elbow room in anticipated lower missile and missile support production costs as they come out of the R&D stage.

Next year, Air Force experts are predicting there will be a great deal more "breakout" of systems items such as launchers, handling gear, fueling systems etc. into competitive bidding.

TRIO OF GIANT plastic-wrapped 1600 KW transformers stand on the Wyoming prairie prior to installation in an *Atlas* ICBM base. They symbolize enormous power requirements and vast quantities of special equipment needed by missiles.

The Army already is following an active "breakout" policy, and the Navy can be expected to also as it moves deeper into the electronics field—both for missiles and its stepped-up anti-submarine warfare program.

The Army will remain a big user of mobile equipment for tactical "artillery" missiles, especially the solid-fueled 700-mile *Pershing,* successor to *Redstone*. Also needed: more compact fire control systems.

• **Need for "doers"**—The missile support field is wide open for newcomers. Says an ICBM-base planner:

"What we need are more doers. Up until now everyone has been concentrating in laboratories and factories on the developing the birds and their support equipment.

"Only now are we realizing that the field—the base—has become an extension of the factory assembly line. And here is where we are having troubles. We need people who know how to get out and work under field conditions and put these systems together so they will work—and on time."

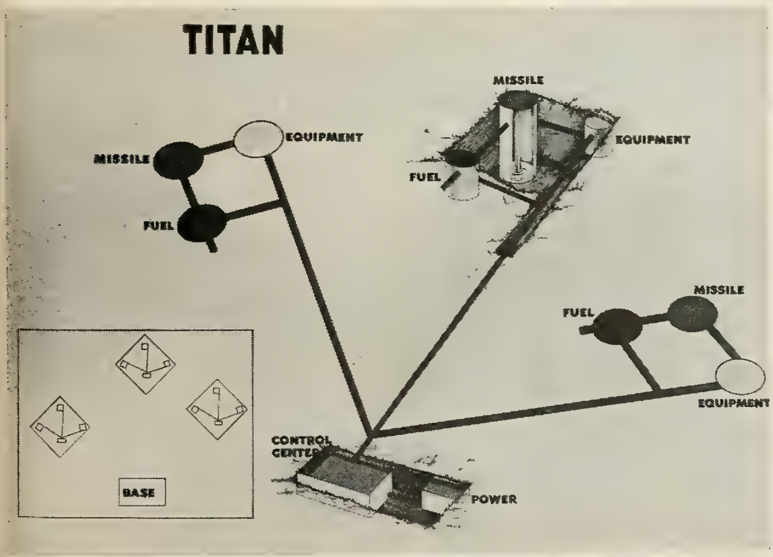
The official told M/R "industry has not recognized the magnitude of the job—in fact, we all have underestimated the difficulty of working in the field."

This points up another problem brought out in an M/R survey of the support field—the great complexity of equipment comprising major systems. Throughout the industry there is demand for greater and greater simplicity in support items, a trimming away of unnecessary automation and "gold plate."

Industry and military people alike connected with the ballistic missile program are infused with a sense of urgency. They want to get the job done the best way as quickly as possible.

"You can't figure out the best way to lift a 110-ton missile out of a 160-foot hole in the ground and launch it, within five minutes, including fueling time, entirely by sitting at a drafting table," says an engineer. "You have to get out there with the missile in the silo and design around the problems you run into."

"There's one thing to remember," he adds. "The big bird has to work perfectly today, next month, next year, in five years, and we hope maybe never. But if it does fly—nothing short of perfection in the support equipment and all the way around will make it hit the target."



FOUR *TITAN* installations are being built now by the Air Force BMD at a cost of more than $40 million each, just for the facility. Equipping a nine-launcher complex costs an additional $47.3 million. Support is 80% of the total system.

COVER STORY

Talos Turns Triple Navy Threat: Anti-Air, Bombardment and AICBM

New Talos to kill planes 100 miles away; Super Talos anti-missile missile may be seaborne defense of U.S. homeland

by James Baar

WASHINGTON—*Talos*—the Navy's pint-sized giant killer—is turning into a key triple threat weapon of the Missile Age.

Bendix *Taloses* are the new "big guns" of the fleet, capable of smashing ships and shore installations with nuclear or conventional warheads.

They are death on missile-launching aircraft at ranges greater than 65 miles.

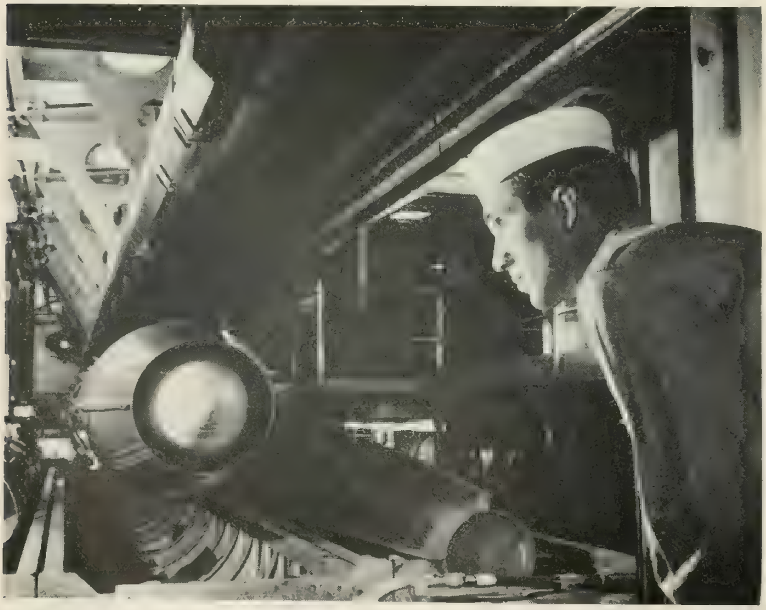
And they are the seed from which the Navy expects to bring forth a possible sea-going anti-missile missile called the *Super Talos*.

These capabilities and potentialities combine to make this rocket-boosted ramjet missile one of the most important in the Navy's missile arsenal.

Hundreds of millions of dollars are expected to be spent for *Taloses* to arm at least seven cruisers by early 1962. Many hundreds of millions more are expected to be spent on *Talos* radars and other shipboard missile support equipment.

These figures are for the present day *Talos* and improved models alone. They do not include the cost of *Super Talos* for which the Navy has high hopes and urgent need.

The highly-secret *Super Talos* would be used to bat down missiles fired against carriers, cruisers and other surface ships. It also might be developed for defense of continental United States against ICBM's and missiles fired from submarines.



TECHNICIAN checks *Talos* in storage area on converted missile cruiser Galveston.

The significance of the development of a seagoing AICBM in the evolution of U.S. strategy would be very great.

A seagoing AICBM would rival the continued development by the Army of **Western Electric's** *Nike-Zeus*. It would greatly increase the need for large surface ships. It might even bring back the battleship as a combined anti-missile missile ship and *Polaris* launcher.

Moreover, in the more modest role as a defense against missiles launched at surface ships, the *Super Talos* would meet a growing threat to the fleet.

Today, once a missile is launched, a surface ship has no defense against it beyond mobility. At present this is still considered effective. But tomorrow, ever-improving guidance will diminish the effectiveness of maneuverability to almost nothing.

• **Sired by Kamikaze**—The history of the *Talos* dates back to the end of World War II when the Navy began searching for a new weapon to use against Japanese kamikaze attacks. To find one the Navy began the top secret *Bumblebee* program at Johns Hopkins Applied Physics Laboratory. A family of missiles—*Talos, Terrier* and *Tartar*—has resulted.

The 7000-pound *Talos* is the heavyweight of the group. Its **Bendix** solid booster and **McDonnell** 40,000-pound thrust ramjet crammed into less than 30 feet of missile give it a speed of Mach 2.5. Its **Sperry-Farnsworth** dual guidance—beam rider and homing—give it a high degree of accuracy. It can operate at more than 75,000 feet.

Improved models of *Talos* will have considerably longer range and greater speed and accuracy. The *Super Talos* now under development is understood to be so far advanced over the *Talos* that it bears little resemblance to it.

However, despite differences, *Super Talos* is being designed as a part of the *Talos* system. For example, the Sperry AN/SPG-49 super radar used on shipboard in the *Talos* system is undergoing further development to enable it to detect oncoming missiles.

The first operational *Talos* was fired from the converted missile cruiser Galveston last February. Next year three more converted missile cruisers—the Little Rock, Oklahoma City and Albany—are scheduled to be ready for arming with *Taloses*.

Present plans also call for deploying *Talos* aboard the nuclear-powered cruiser Long Beach and the converted missile cruisers Chicago and Columbus. The Long Beach will be operational in 1961; the Chicago and Columbus in early 1962.

Talos will serve on all of these ships in its double role of an anti-aircraft and heavy bombardment weapon.

As anti-aircraft, *Talos* is designed to defend surface ships from air-launched missiles by striking missile-carrying aircraft before the missiles are launched.

Its effectiveness in this role is improving as its range is extended. Current designs call for extending its present range of about 65 miles to about 100. Later plans call for pushing the range even farther out.

- **The big punch**—As a bombardment weapon, *Talos* has become the successor to the old 16-inch gun—the former big punch of the fleet.

The missile—a little more than twice the weight of a 16-inch shell—can smash a surface target with either a conventional warhead of significant size or a nuclear warhead. Its rate of fire is believed to be at least as good as the two-a-minute rate of the 16-inchers. And its present range is four times as great.

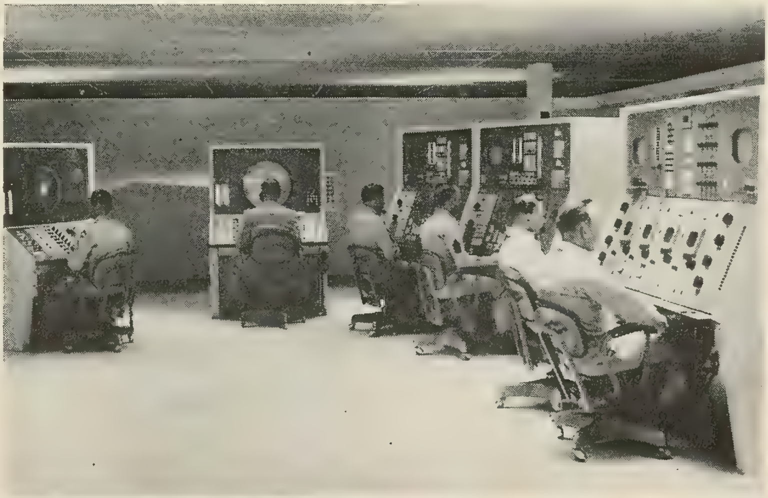
In action, *Talos* will complement its smaller cousin—the **Convair** *Terrier*. The 10-mile range *Terrier* with its conventional warhead serves both as anti-aircraft and a bombardment weapon.

The trend is clear. Conventional guns are being stripped from the fleet at an increasing rate.

The missile cruisers Canberra and Boston are partly equipped with *Terriers* and partly with eight-inch guns. The *Talos*-armed Long Beach will carry no guns at all.

In the years ahead, the symbol of tactical seapower is certain to be more and more the long shadow of the blunt-nosed *Talos* and its successors.

LAUNCHER, trained and elevated to starboard, holds a brace of triple threat *Taloses*. Successor to the 16-inch gun as the Navy's "big punch," the Bendix missile is being deployed aboard several cruisers and its range is constantly being extended.



HEART OF the *Talos* defense unit is the fire control center, where consoles are arranged in a soundproof room with shadowless lighting. During full automatic operation, operators merely observe; but they can inject elements of judgment.

'Articulation' Solves *Talos* Handling

High-speed movement from magazine to launching deck is engineered by an articulated rack which drives missile hoist

by R. A. Burt

PITTSFIELD, MASS.—One problem in the design of the *Talos* shipboard missile-launching system was the transfer of missiles from the below-decks magazine to the level of the launching deck.

In the *Talos*-armed ship, space allocated for hoisting machinery is below the hoistway, rather than above as in more conventional land-based hoist systems. This dictated a "push up" instead of a "pull up" hoist design. Basic hoist power, two 60 HP direct current electric motors controlled by variable voltage from a motor generator set, is physically located below the magazine.

The magazine must be sealed from the rest of the launching system by a gas-tight door at the level of the launching deck. The hoist must lift missiles up through the magazine door during loading operations, but permit a tight seal of the magazine during preparation for launching and actual firing of the missile. This requires a hoist configuration without any complicated mechanical parts to interfere with effective magazine door seals.

Talos is the largest and heaviest of the shipboard surface-to-air missiles. The dead weight of the hoist and load (missile and stowage tray) is 32,000 pounds. This must be moved with speed and precision a vertical distance of as much as 35′.

To meet these requirements, **General Electric** engineers considered a number of alternate designs. Tension arrangements using cable or chains, and compression designs using chains, gear racks, screw jacks and pistons, were evaluated. The design selected is a direct gearing device consisting of a stationary axis pinion which engages and drives a moving rack. One of the unique features of the hoist drive mechanism is a gear rack having joints which allow the rack to articulate or bend into a sharply curved shape.

- **Rack guides**—At either end of the hoist platform are attachment points for the articulated rack. The hoist structure is constrained by hoist guide rails to move only in a vertical direction. The same guide rails also constrain the articulated rack from lateral and axial motion.

At the bottom of each hoist rail is a housing which contains the drive pinion. Mechanical shafting connects each pinion through a worm gear reducer to its electric drive motor. The two drives for either end are then connected together by a synchronizing shaft which keeps both hoist ends accurately aligned.

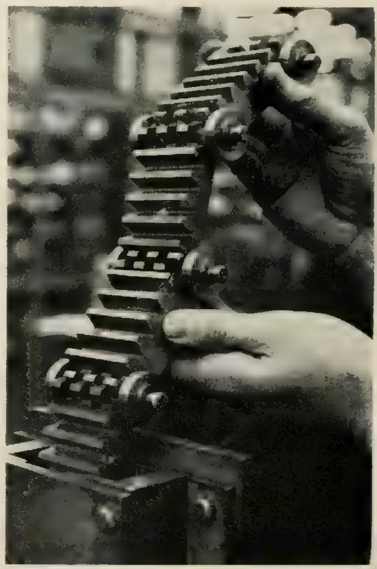
Below the pinion boxes are curved rack guides which bend into a horizontal position. Whenever the hoist is lowered the unloaded sections of the articulated rack pass out of the bottom of the pinion box and into the horizontal rack storage housings.

The hoist guide rail provides for guiding and restraining the rack. Positions of the rack which are actually supporting the hoist load are under a substantial compressive load and need constraint to prevent buckling at the joints. This constraint is provided by rollers mounted at each rack joint. These rollers fit closely into the hoist guide rail. Axial constraint to prevent column buckling of the rack is achieved by caps on each end of each rack joint pin. These caps bear against opposite ends of the hoist rail cavity and thus support the rack throughout its entire stressed length.

Even more accurate guiding and constraint of the rack is required at its mesh with the pinion. Here the rack-pinion mesh is strongly constrained against tooth separating forces but weakly constrained in the vertical—axial plane.

Tooth separation loads are carried by shaft mounted rollers which bear against the back of the rack sections at the pinion mesh. The roller axis is located at the vertical position which provides correct balance of the average resultant load force and pinion tooth force. The other two rollers give additional stability to the gear mesh as well as providing for negative hoist load conditions.

- **Gear tooth alignment**—Weak constraint against axial movement and angular movements in the axial-vertical



MINIATURE model is one-third actual size of rack articulation developed for *Talos*. Rollers fit closely in rail.

About the Author

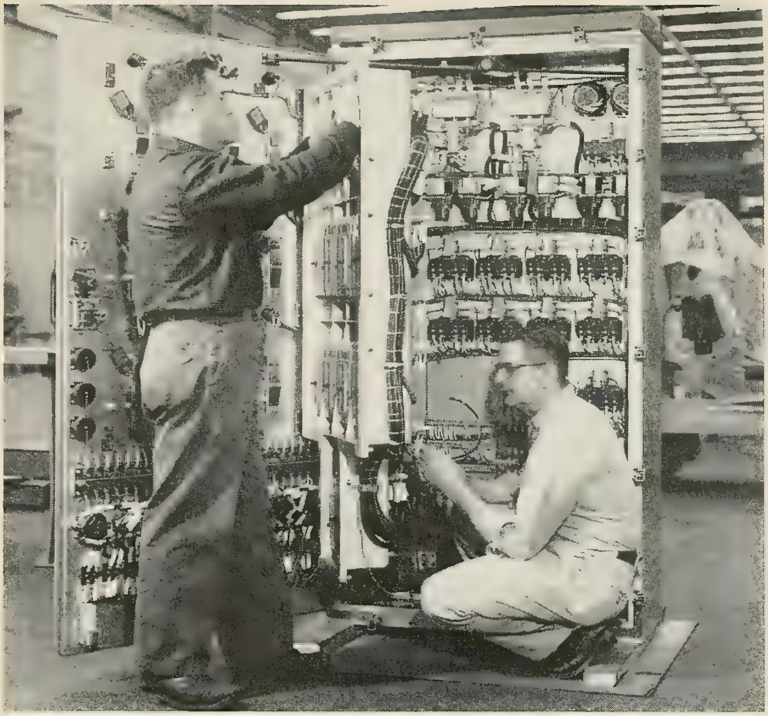
Mr. Burt is an advanced mechanical design engineer in the Ordnance Department of General Electric Co., developer of the multi-million Talos Mark XII missile launching system which will be installed aboard nuclear-powered cruisers.

plain are obtained by the springs at each rack pin joint. At either end of each pin point are Bellevielle springs interpositioned between the rack section and each end cap. By allowing slight angular adjustments of the rack in a vertical plane, some self-alignment of the rack and pinion teeth occurs and concentration of loads at the tooth edges is avoided.

To achieve a satisfactory rack joint design, accurate gear tooth alignment must be obtained without sacrificing load capacity of either the gear teeth or the rack structure. Although compression loads predominate, there are momentary tension loads of substantial magnitude which must be carried by the rack. The joint design chosen is a multiple tongue and curve configuration pinned at the tooth center line. Accurate location of the pin hole with respect to the tooth faces allows reasonable tooth load division between portions of the interlocking rack sections.

There is an optimum location of the bore for the rack joint pin with respect to the tooth and the rack body which equalizes the strength of the joint against the various failure possibilities. For instance, breakage might occur straight across the base of the tooth or a break might occur from the tooth fillet into the pin bore. Repetitive stress tests were made on models with several different hole locations. Results of the tests were used as a basis for selecting the optimum hole location for maximum all around strength.

Lubrication is provided by both oil bath and pressure jets. An oil tank is built integral with the curved storage housing. As rack sections pass through the low point of the storage housing they are immersed in oil. In addition, a small pump feeds oil to a series of jets located at the point where gear rack teeth mesh in the pinion box.


CONTROL cabinet for *Talos* launching system. Panel provides power distribution for launcher power drives, missile warm-up power and control power supply portions.

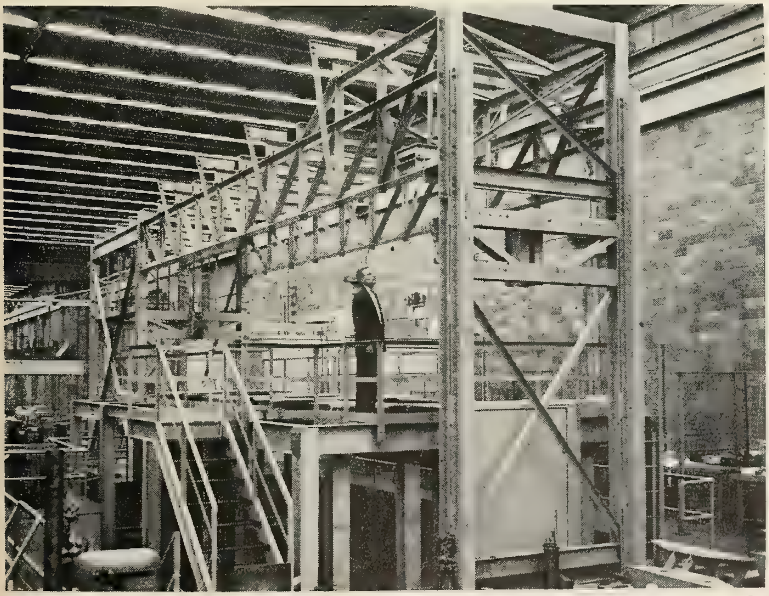
• **Absorbs bulkhead "breathing"**—The articulated rack design appears to be the best all around solution for the requirement of the shipboard *Talos* magazine hoist.

The magazine door seal becomes relatively simple. All of the moving hoist platform and drive parts can be retracted into the magazine and the hoist rails can be switched out of the doorway. Only a simple flat surface is left to be sealed.

A relatively small diameter pinion can be used with the rack-pinion design. As a result, the total gear reduction can be accomplished in one stage of reversible worm gearing. Substantial weight and space savings are thus obtained. Direct gearing also introduces little or no "pulsation" in the rotary to linear motion conversion such as is inherent in linked chain drives.

The effects of distortions of ship structure become negligible because the rack joints are parallel to the relatively stiff ship bulkheads and perpendicular to the direction in which maximum distortions of the local ship structure are expected. As the magazine bulkheads breathe back and forth, this motion is readily absorbed by articulation at the rack joints.

Articulation of the rack does appear to add complications to the design and manufacture of a gear rack. However, in an overall appraisal, articulation is the feature that makes possible a simple compact drive.


HOIST built by General Electric weighs, without missiles, 350 tons, making it the largest piece of ordinance in the Navy. Power is directly below the magazine.

Big Rockets Multiply MSE Needs

Trend is toward reducing sophisticated engine equipment. But man-in-space requirements, new fuels will demand R&D of new support items

by Henry W. Gilfillan

CANOGA PARK, CALIF.—Designers of rocket engine support equipment face a variety of new problems. These are occasioned by the larger and larger powerplants that are and will be required and the introduction of new propellants, both of the storable and high-energy types.

New problems are the result of our insatiable ambition to achieve greater and greater things in rocketry. The diminution of some of our old problems is due partly to the fact that our hardware is becoming simpler and more reliable, requiring less field checkout and routine maintenance.

The greatest thing, of course, that ever happened to support equipment was its recognition as an important part of the weapon system, the realization of its true extent and cost, and the intensity of effort which this realization triggered.

One of our past problems has been simply that of learning to analyze functional requirements realistically and of coordinating properly, both internally and externally. A few years ago it was hard to get the attention of an engine designer long enough to consider support matters. He was, understandably, too preoccupied with the more glamorous and apparently much more pressing job of developing a good reliable engine. It was difficult to coordinate properly with associate contractors concerned with the same weapon system, in matters relating to "integrated" support equipment. That is, equipment generated primarily by engine requirements, but whose design must be coordinated with missile systems or missile supporting equipment.

Examples of integrated MSE might be special slings for installing an engine into a missile airframe. The pickup points, of course, are determined by the engine itself, but other dimensional requirements are determined by the airframe and the methods of engine installation to be employed—horizontal installation, for instance, for *Jupiter*, or vertical for *Thor*. Another example would be electrical launch controls, with their intimate interconnections with missile circuitry and MSE. In these cases, it was hard to determine the inter-faces of responsibility.

In the early days, the maintenance concept was just evolving and the serious impact on design of maintenance analyses, belatedly conducted, was not yet fully appreciated.

• **R&D and standardization**—The press of time was an added factor. Support equipment engineers have always been hardest hit by schedules. They were generally handed a nearly operational missile design and then told to go ahead and design and develop operational MSE and get it to the armed forces well ahead of the airborne hardware. This left them no time for R&D. It is a matter of history that our precious prototypes were sometimes reluctantly relinquished in order to meet first production delivery schedules. As a result, we were really forced to develop our equipment while it was in production or actually in the field. We have now come to regard R&D concurrent with production as normal.

Another matter of concern was that of standardization between weapon systems and space vehicles. No one will argue against standardization as regards design and development time and overall cost. But, in the past, it has sometimes been difficult to persuade the "program" or "project oriented" people to accept any design or performance compromises that would be solely in the interests of standardization.

In the matter of configuration control, we have had to learn to evaluate changes in airborne hardware properly with respect to their effect on support equipment. We have come to appreciate that what may sometimes seem to be an innocent improvement to a missile may wreak havoc with the correspondingly affected support equipment as well as with handbooks, spares, trainers, training courses, and logistics in general.

We have had to learn to resist certain rather human temptations. Developing automatic checkout equipment, for instance, is a fascinating pursuit. But we must take care not to over-automate unnecessarily just because it is more fun to do it that way. We have had also to avoid a tendency to perpetuate 'traditional' system and component checkout procedures that are no longer really necessary.

• **Eliminating sophisticates**—It used to be considered mandatory that an engine system be checked out using actual launch control equipment. This is a good philosophy during R&D, when changes are extremely rapid and when it cannot be guaranteed that launch control equipment is truly compatible with the engine until they are checked out together. In an operational situa-

About the Author

Henry W. Gilfillan is section chief for the Ground Support Equipment unit at the Rocketdyne Division of North American Aviation. He is responsible for all the engine handling equipment for Redstone, Jupiter, Thor, Atlas, Saturn booster, and Nova F-1 programs. After obtaining a BS in electrical engineering at the University of Michigan in 1939, he was a research engineer with Chrysler Corp. until 1951, when he joined Rocketdyne as a senior engineer in research. He directed development of electrical control components until last year, when he took over his present assignment.

tion, however, there is less of this uncertainty, and, consequently, checkout equipment can be considerably simplified in engine and missile maintenance areas. It was found that under the old philosophy, most of the time required to checkout an engine was really spent in checking out the launch control equipment instead.

We were forced also to comb through our procedures and handbooks and weed out unreasonably accurate or unnecessarily sophisticated field checkouts which would require correspondingly sophisticated and complicated support equipment. We had to rouse ourselves occasionally from our preoccupation with engineering elegance of design of airborne equipment and from our lack of concern for down-to-earth, potentially wartime, field conditions. Engine designers have learned to be a trifle more thoughtful about including some very minor design provisions to meet support needs. We remember how we all once wished very much that one more lifting lug had been provided on one of our engines.

- **Reducing MSE—Rocketdyne** recognizes that the only sound, fundamental way to reduce the cost and amount of MSE hardware is to develop simpler, more reliable engines and components which need little in the way of field checkout and field maintenance.

For example, the single thrust chamber engines we were building in 1955 were comprised of 88 components. Our 1959 models have only 33, and our 1960 engines will have only 5 components. This, of course, results in much higher engine reliability and in greatly reduced MSE. Regrettably, the amount of MSE is not reduced in direct proportion to the reduction in components, but the effect is gratifying indeed.

The other part of the Rocketdyne approach hinges on proper timing. As has been pointed out many times by support people, design of support equipment should begin concurrently with the design of the missiles and engines themselves. There is a danger, however, of starting to draw pictures too soon. The trick is to start actual design not too late—but not too early either. In the inception of a missile design, the following begin at the very outset:

- Investigation of the vehicle or weapon system operational concept.
- Investigation of the maintenance concept.
- Investigation of engine system support functional requirements.
- Investigation of engine component support functional requirements.

Following these, model specifications are written (whether or not there is a contractual requirement for them). These spell out all functional design requirements of each support item insofar as they can be determined at this stage. Then all sources of existing equipment, i.e., military inventories, commercially available equipment, and equipment already developed for other programs, are investigated. If it is suspected that other contractors may already be developing equipment with similar functional requirements, this is investigated too.

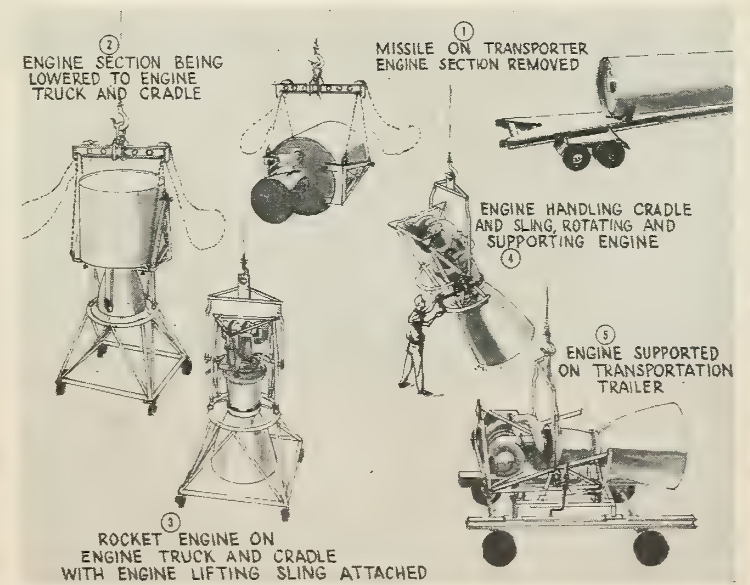
We have developed a number of semi-standard modules, especially in the checkout and servicing areas, which can be applied "as is" or with small modification to most new engines, missiles or space vehicles. New prototype design begins only when functional requirements are firm enough to result in prototype hardware that will be reasonably close to the final operational configuration. Final production design release is held up as long as possible without jeopardy to customer need dates. In this way, prototypes are available for development for as long a period as possible.

- **Compatibility**—In order to tie the knot of coordination securely between engine designers and support equipment designers, it is now required that they sign each other's layouts. Thus, the engine people can be assured of functional and configurational compatibility of the MSE with their engines and, in turn, the MSE designer can adequately be assured that proper design provisions have been made for engine handling, servicing and checkout. As a final safeguard to guarantee compatibility, Rocketdyne now regularly conducts "RIOT" (Resolution of Initial Operational Techniques) programs. These are in the nature of validation tests, wherein the engine, its support equipment, the handbooks and the man who has been trained to use all three, are all brought together and operated as nearly as possible as they will be in the field. Thus the last remnants of incompatibility are picked up and corrected.

Finally, Rocketdyne operates what are known as flight test support stands. These are engine test stands which have been equipped with operational ground support equipment insofar as feasible. Our past problems have been less of a technical nature and more a matter of finding out what things to do rather than how to do them. Recognizing the harmful effects of poor human engineering, consultants to Rocketdyne have produced a Human Factors design manual for support equipment. Classes in human factors principles are conducted regularly by a qualified expert who also approves all MSE design layouts.

Of more pressing interest are the more technical obstacles that confront us immediately.

- **Big rocket MSE**—The physical size of some of our new engines, for instance Rocketdyne's 1.5 million-pound-thrust F-1 single-chamber *Nova* engine being developed for NASA, poses some unusual handling and transport problems. Since it is desirable to position the engine at several different angles during the process of fabrica-



EQUIPMENT used to remove *Thor* engine and ready it for trip to maintenance area.

tion, special handling equipment must be provided in the shop. With regard to transport, there are definite size limitations relating to bridge and tunnel clearances as well as allowable or desirable load width on the highways.

Special consideration will also have to be given to the limitations of highway, rail, air and water transport. At the test stand or launching site, too, the handling problems incident to installation and removal of the engine are not to be dismissed lightly.

The size of certain of the engine control components presents problems. We are used to thinking of engine propellant valves as being something smaller than a breadbox that one man could pick up and carry. This is by no means any longer the case, and special handling and protective gear must now be provided for them.

Again because of size, decontamination equipment for these large engines must be correspondingly scaled up to provide higher pressures and higher flows of solvents, and purge gases. Thrust chamber protective covers and closures, heretofore considered minor design problems, now require careful comparative analysis and design study in order to arrive at configurations which actually do protect the engine and yet are made up of subsections small and light enough that special handling equipment is not especially required for them too.

Happily, increased size has not resulted in increased difficulty of engine checkout or in complexity of checkout equipment. In fact, the simplicity of this particular engine has considerably reduced checkout requirements as compared to current production engines. With some new engines, however, checkout equipment has been complicated somewhat by the addition of new systems such as helium cryostats.

The *Saturn* vehicle being developed for ARPA by the Army Ballistic Missile Agency, and for which Rocketdyne is developing the booster propulsion, employs a cluster of eight engines similar to those now used on the operational *Jupiter* missile. Fortunately, again, clustering presents no particularly new support equipment problems. Engine installation gear may be a trifle more difficult than for an IRBM, but the "any position, plug-in" engine imposes no new requirements on checkout or servicing equipment.

On the other end of the scale, some of the new engines now being developed by the industry for application to upper stages, have thrust chambers which are extremely lightweight. Special handling and protective devices are required.

The new silo launcher configurations, now projected for various weapon systems, impose no significant hardships on the design of engine support equipment, but may possibly exert a larger influence on the support devices associated with the rest of a weapon system, such as propellant loading gear or missile handling or missile checkout equipment.

• **Space support needs**—Let us take now a very brief glimpse at some of the anticipated problems of the future. The trend seems to be toward higher pressures in missile pneumatic and hydraulic systems, possibly up to 8000 psi.

This will require the development of greatly improved fittings and hoses capable of satisfactory performance and safety at these higher pressures for use in fluid systems.

Enormous size and expenses of first-stage boosters for some of the currently contemplated space vehicles makes it extremely desirable, probably economically mandatory, to develop booster recovery techniques. What new support requirements will be thus generated is not yet known, but it can be foreseen that ships or landing fields and communication systems will be required and also engine cleaning and overhaul facilities. The cost, in the opinion of the writer, will be fully justified by the dollar savings in booster hardware.

The same applies, of course, to the recovery of the man, or men, in a space vehicle. The extent and cost of the ground support required will be large, but this is critical to putting men in space. With manned vehicles, it may be necessary to protect the pilot from the noise developed by his vehicle's engines, especially at blast-off. And it may be possible to ameliorate this condition by means of special support equipment, the nature of which we can now only guess at.

The potential effects of storable propellants upon support equipment appear to be beneficial. Propellant transfer will be a less frequent operation and it will no longer be necessary to employ topping techniques during holds. The use of storables actually forces a reduction in checkout and in maintenance operations, as it is usually not practical to exercise valves and control components for purposes of checkout or to remove and reinstall components from a propulsion system when the missile tanks are already full. Other simplifications are also inherent.

For instance, the propellants are hypergolic and need no special ignition systems for starts, or restarts aloft, and, consequently, ignition system checkouts are eliminated. About the only new problem that storables introduce is that of propellant leakage detection and the disposal of propellants thus lost.

• **Simplification trend**—High-energy propellants, on the other hand, pose very difficult support problems. Liquid hydrogen requires special liquefaction storage, transportation and line-transfer equipment because of its extremely low boiling point (minus 420°F). Liquid fluorine has the same disadvantages plus some extremely difficult materials problems. Passivation and cleanliness requirements force the development of new handling items.

Simplification characterizes future trends in rocket engine support. Vastly simplified engines both in being and projected will require very little checkout. New techniques of induction-brazing plumbing will virtually eliminate leaks and the need for leak-test equipment.

Simpler components will foster simplification of support gear. Hypergolic igniters and burst diaphragms, for instance, cannot be checked out and hence do not generate supporting devices. Equipment for cold checking in the field will also disappear as it is becoming safer and safer to assume that a component assembled per print with parts that are dimensionally correct will function properly under all conditions for which it was designed. Highly sophisticated items like servo valve analyzers will fade from the operational scene.

Future engines will be capable of being flushed, purged and preserved while in any position, eliminating special handling and rotating gear now in use. The utter simplicity of new engines and almost complete lack of an electrical system may eliminate automatic checkout of engines.

Technical breakthroughs can and must be made by the designers of airframe hardware, guidance systems, engines and the researchers in fuels, materials and futuristic propulsion systems. To be sure, support equipment designers will make use of the new knowledge and techniques thus gained by their less earthbound brethren in order properly to support the winged things of the future. Missile support (and space support), however, will hold up its end by making "conceptual" breakthoughs—researching the new ways in which men in space must be supported and maintained alive until they and their vehicles are successfully recovered intact.

MOTOROLA MILITARY ELECTRONICS CAPABILITIES REPORT:

Strategic Deployment of Technical Personnel

Dr. Daniel E. Noble, Executive Vice President, Motorola, Inc.

"Dynamic organization...not static...is the key to productive use of technical talent in the field of military electronics."

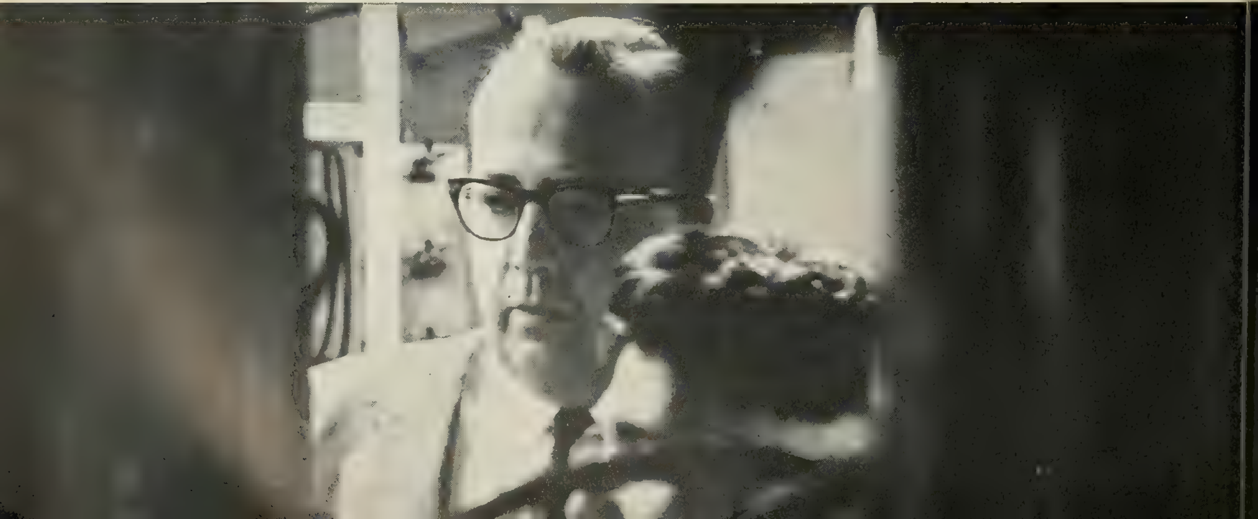
The next two pages tell how Motorola has achieved "dynamic organization" . .

William S. Wheeler, Vice President and General Manager
Military Electronics Division

Arthur Reese, Vice President and General Manager
Communications Division

Three field commanders direct day-to-day activities of Motorola's technical divisions. Wheeler's Military Electronics Division concentrates directly on military problems, drawing on the resources of Reese's Communications Division (world's largest producer of two-way communication systems) and Hogan's Semiconductor Division (world's largest producer of power transistors and leader in mesa transistor development and production). Behind this technical task force stands Motorola's strength in consumer electronics; in an emergency the company's total complex of 18 plants in four states can be converted to mass production of military equipment.

Dr. Lester Hogan, Manager
Semiconductor Products Division



Of Motorola's 2,000 engineers and scientists, four out of five work under the direction of Dr. Daniel E. Noble, Executive Vice President. One of the three divisions under his command is devoted exclusively to military electronics; two others provide strong support. Working together, they form a

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Officials of the Air Force Flight Test Center at Edwards faced a particularly knotty problem. Specialized microwave equipment was required to relay telemetry from aircraft in remote areas.

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Few organizations serving the military today can so rapidly merge diverse technical talents and productive capacities as can Motorola. Its three "task force" divisions, under the single command of Dr. Daniel Noble, can be marshalled almost overnight for the solution of urgent military electronics problems. Cross-fertilization of ideas and techniques is the certain result.

The success of this flexible organizational structure was again demonstrated by Motorola's part in the development of the Project Mercury Space Capsule. The Capsule's command control receiver, developed by Motorola's Military Electronics Division, is the smallest all-transistorized radio receiver of its type available, thanks to mesa transistors developed by the Semiconductor Division and miniaturization techniques borrowed from packaging specialists of the Communications Division. In another instance, Motorola's Semiconductor Division developed the first samples of a new type of electronic facsimile paper with important military applications.

In an era marked by a chronic shortage of competent brain-power, Motorola's strategic deployment of its technical resources is an effective answer, both in the solution of current problems and in conducting long-range research.

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Pre-cooling To Eliminate Countdowns?

Retractable cooling jacket is suggested to prevent cryogenic boil-off; ICBM bases require 25 T/D LOX-liquid nitrogen plants

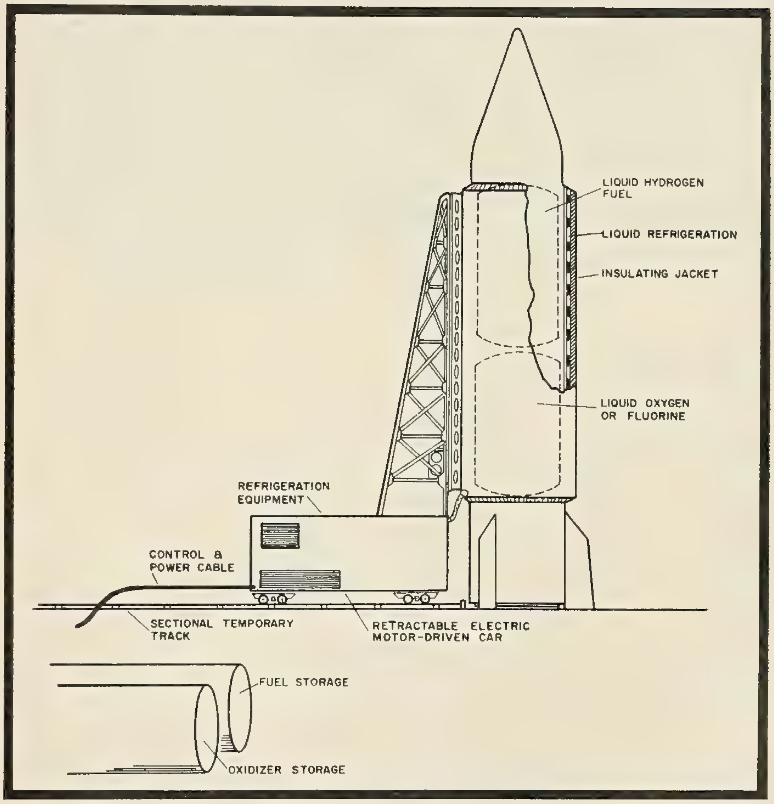
by James A. Snyder

ALLENTOWN, PA.—Among the disadvantages associated with high-performance cryogenic propellants is the long countdown period. This remains after such other difficulties as mobile production and handling have been overcome.

One method of drastically reducing or even eliminating the countdown time would be fabrication of a retractable, refrigerated missile jacket. This device would pre-cool the missile prior to fueling and then maintain both the fuel and the oxidizer in a slightly subcooled condition in the missile, thus eliminating boil-off. The jacket could be removed just before launching. Different zones of the jacket could be held at different temperatures to accommodate the particular fuel-oxidizer combination in use at the time. The system would assure the presence of the exact amounts of propellant necessary at the precise instant of launching.

Since the airborne cryogenic equipment contained in the missile would be at low temperature, the possibility of thermal shock as a source of malfunction would be eliminated.

It is doubtful that this adaptation will be made to the present generation of vehicles, but it shows great promise for future high-performance equipment. Meanwhile, advances have been made in adapting the production and handling of cryogenic propellants to field conditions.



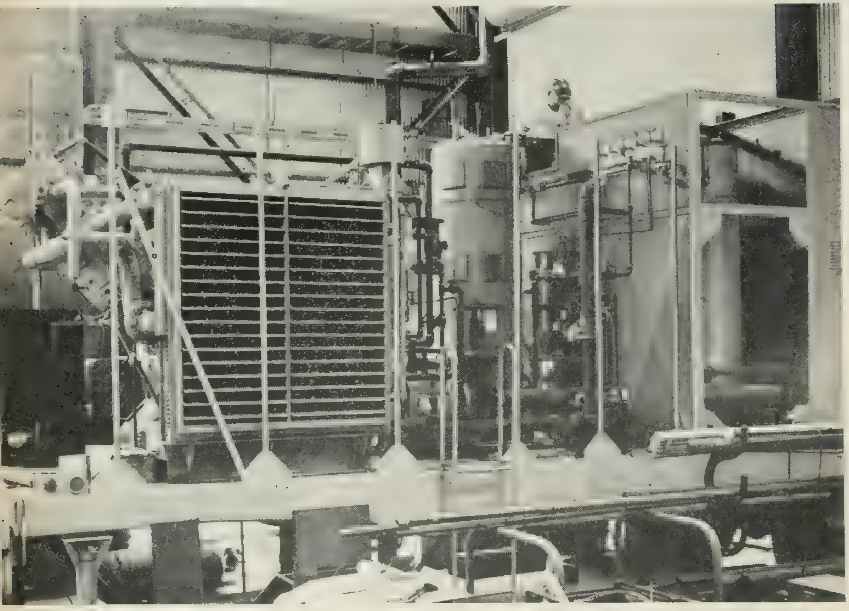
RETRACTABLE refrigerated missile jacket could assure right amount of launch fuel.

• **Mobile LOX systems**—The *Redstone* missile—being highly mobile—required a LOX generating plant which could be built into military type semi-trailer vans, and able to meet all the normal military requirements such as terrain, climatic conditions, gee-loading and air transportability. The plant employs the use of a somewhat standard high pressure cycle and produces 5 tons per day (T/D) of liquid oxygen.

In field use, the only support raw material needed is diesel fuel for the engines driving the compressors. These units generate their own electricity for auxiliary purposes. LOX or liquid nitrogen is withdrawn from the appropriate liquid storage tank aboard the trailer and is transported to the missile in a military type, 9 T/D LOX trailer. This trailer has a self-contained

About the Author

James A. Snyder is manager of the Government Projects Division of Air Products Inc. Holder of an MS degree in mechanical engineering from Columbia University, Snyder is closely associated with LOX and liquid hydrogen production in both large permanent plants and mobile support systems.



HELIUM liquefier was built by Air Products to test feasibility of long-range transportation of the material. The next few years will bring heavy work in this field.

liquid transfer pump which pumps the product directly into the missile.

The *Jupiter* system, with considerably larger demands than the *Redstone*, required the development of a liquid oxygen-liquid nitrogen producing plant having total liquid capacity of 20 tons per day. Once more, the mobility concept prevailed and in this instance it was necessary to use four semitrailer vans to house the essential equipment. Again, all of the military vehicle requirements applied. Two air source trailers are needed, along with a third housing air purification and heat exchanger equipment.

The fourth contains the control room, expansion turbine, distillation column and plant storage tanks. In field use, LOX or liquid nitrogen is transferred from the generating plant to a 4000-gallon military-type liquid semitrailer. A sufficient number of trailers to fill one missile are hauled from the generating plant site to the actual launching site where the product is transferred from the trailers to the missile by means of a separate transfer pump.

The required suction head for the LOX transfer pump is provided through pressurization of the liquid in the trailer by coils located on the underside of each trailer. Appropriate filtering equipment is used to avoid the introduction of mechanical particles into the missile itself.

- **Transporting by air**—Other major missiles in our arsenal employ the concept of a semi-permanent or permanent base, such as the *Thor*, *Atlas* and *Titan* programs. The LOX generator concept then changes from one of extreme mobility to one of air transportability for these semi-permanent or permanent locations. For this service, a 25 ton-per-day liquid oxygen-liquid nitrogen generating plant was developed with the main power source being either diesel engines or electric motors. Again, the plants are designed so that the main support requirement will be easily available. A high-pressure cycle similar to the *Redstone* is used, except that more refinements such as expansion engines and more effective control systems are employed to provide a plant having a greater over-all economy.

In all instances, the plants are designed to be operated and maintained by military personnel. All components, including the building, form convenient packages for air transportation. In these bases, LOX is moved from the generating area to the launching area by means of 4000-gallon semitrailers. The storage tanks are generally 28,000 gallons and pumping from the storage tank to the missile is accomplished by means of a pressurization system. High-pressure storage bottles are filled with vaporized LOX at a pressure of approximately 3000 psig, and an elaborate control system is employed to fill the missile quickly with LOX and to keep it topped with sub-cooled LOX during the pre-launching period.

- **New standards**—As the missile program developed and the equipment and systems became more complex, new requirements for quality control became apparent. Commercial standards of cleanliness and purity were no longer satisfactory. As a result, a hydrocarbon analyzer was developed and forms a part of the scientific equipment associated with each of these installations. It is used to detect contaminants in the fractional parts per million range which, if concentrated, could cause explosions.

Similarly, mechanical contamination became a problem. It was necessary to develop new standards of cleanliness for all LOX handling equipment. A system had to be devised for protection against the introduction of the contaminants during the various rehandling operations. There is still no universal agreement among the missile manufacturers on this point, but generally filters capable of removing mechanical particles down to a minimum of 10 to 40 microns are used.

Another specific missile development is storage tank decontamination. A device has been developed which will allow periodic removal of either soluble or non-soluble contaminants by means of adsorption techniques without the necessity for discarding the contents of the tank.

- **Liquid Hydrogen**—Now that the security veil which has surrounded the liquid hydrogen program has been lifted, it is possible to discuss some of the outstanding developments in this field. Liquid hydrogen is the most promising new fuel in the missile business today.

Users feel that the increased handling problems are more than offset by the remarkable high performance of this fuel. In contrast to liquid oxygen, liquid hydrogen has a boiling point of –423°F., a critical temperature of –400°F., and a freezing point only 14° below its boiling point. This very light liquid has a density of only .58 pounds per gallon and a latent heat of only 389 BTU's per pound-mol compared to that of 2932 BTU's per pound-mol for oxygen.

Thus it can be seen that the liquid is very cold, that it will occupy large volumes on a weight basis, and that it has a tendency to boil away at a much faster rate than the familiar liquid oxygen. However, its specific impulse when used with LOX is approximately 365, as compared to a specific impulse of approximately 270 for RPI and LOX. Of the known chemical fuels and oxidants, this impulse is exceeded only slightly by the combination of hydrogen and elemental liquid fluorine.

A hydrogen production and liquefaction facility is necessarily complex. The basic source of hydrogen is crude oil, with additional hydrogen being extracted from water during the chemical processing which takes place in the hydrogen gas generation portion of the plant. The hydrogen is liquefied by first being cooled to liquid nitrogen temperatures by means of a nitrogen refrigerant system and further cooling in a hydrogen refrigerant system—with final refrigeration being supplied through mechanical expansion devices especially developed for this application.

Large-scale production of this important chemical has proved to be safe and economical. The price of product on a per-pound basis is well below that of some of the more common storables such as hydrazine.

After production, the liquid hydrogen is stored in vacuum insulated storage tanks which have been developed to a state of perfection so that only a very small loss rate (a fraction of 1% per day) is experienced. It is, however, necessary to transfer this product through vacuum insulated transfer lines as opposed to bare or non-insulated lines for LOX or liquid nitrogen. These lines require precision manufacture to maintain the high vacuums, less than one micron, required for successful operation.

Special shielding techniques to eliminate infrared radiation into the product had to be developed. Hydrogen is transferred from the storage area either by direct pipeline or with the use of large liquid semitrailers developed especially for this service. Safety techniques have been developed to the point where it is possible to transport the product over long distances on public highways. However, generally speaking, the economics of the situation indicate the desirability of the location of the production liquefaction plant at or near the missile firing site.

In addition to its use as a chemical fuel, hydrogen has been selected as the ideal propellant for use with the nuclear rocket engine. No new techniques in handling or storage of this fuel are needed for the nuclear missile program.

• **Liquid fluorine**—Because of a shortage of funds for development last year, the liquid fluorine program did not receive the amount of attention which would normally have been indicated by the technical progress made in this field. Next to ozone, elemental liquid fluorine is the most powerful chemical oxidizer known. It has a normal boiling point of –306°F., a critical temperature of –207°F., and a latent heat of 2952 BTU's per pound mol. Thus, excepting for its extreme chemical activity, it is in its physical respects, very similar to oxygen. In addition to being extremely active chemically, it is lethally toxic and thus requires very special handling.

Elemental fluorine is produced by the electrolysis of HF, and various chemical and physical techniques or combinations thereof are employed to remove the impurities carried over from the electrolytic process.

The high toxicity of the element increases the complications in storing and shipping. For instance, the outer shell of a fluorine storage and transport tank contains an intermediate shell which surrounds the inner fluorine tank.

The space between the intermediate and inner shells is filled with liquid nitrogen which is allowed to boil at its normal temperature, –320°F., thus maintaining the fluorine itself in a subcooled condition. This means that fluorine can be handled with these loss-free containers, thus preventing escaping gases and the resulting attack on people or materials.

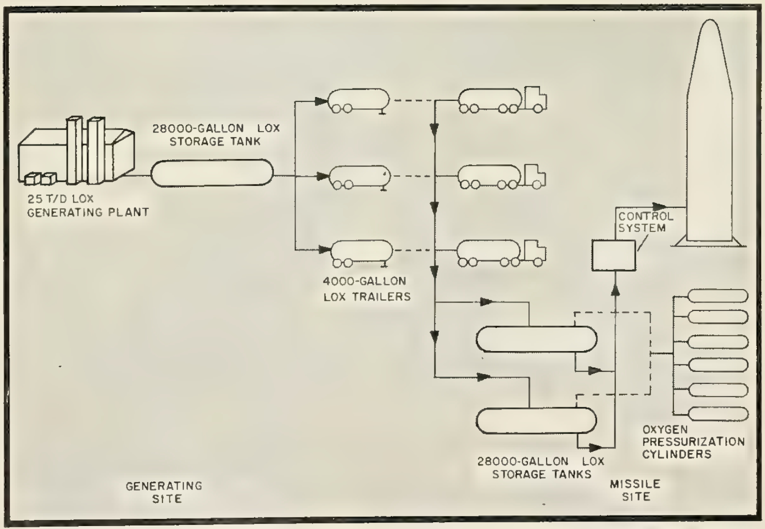
One of the major problem areas in this program has been the development and selection of materials suitable for containing the fluorine under the various operating conditions likely to be encountered. The materials used in handling equipment must often be passified, that is, they are first exposed to a weak fluorine solution which forms a chemical film on the surface of the metal, thus protecting it from attack by the stronger fluorine itself.

Because of the extreme hazards associated with the transporting of this material, it is considered better to locate the production sites as near to the use sites as possible. It is anticipated that activity in this field will increase greatly during the next few years.

• **Future needs**—It is certain that further improvements will be made in the manner in which the liquid propellants are transferred from their storage areas to the missile itself. For example, research is being done on various high-capacity pump systems. Various transfer systems are now being used and it would appear that one superior system will emerge.

The use of the extremely cold cryogenic materials such as liquid hydrogen or liquid helium has required the development of superior insulations and, more important, the application of these insulations to the appropriate tank or line configurations. Several manufacturers are developing proprietary insulations with performances many times better than the familiar perlite-vacuum low-temperature insulation technique. Generally, these new materials successfully shield against infrared penetration while retaining their low-conduction characteristics.

Finally, the area of helium liquefaction will receive much additional attention and development during the next few years. A helium liquefier was developed primarily for feasibility work. This program will demonstrate the practicability of long-range transportation of liquefied helium. This will, of course, greatly reduce transportation costs, as well as the size and bulk of the equipment required for transportation. As more helium becomes available for missile use, liquid storage and pumping systems will be developed as well as the recondensation apparatus necessary to conserve this very scarce element.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GENERATING SITE
MISSILE SITE

LOX SYSTEM for *Thor, Atlas* and *Titan* is designed for operation by military crews.

Space Support Market On the Rise

NASA's support outlay has been limited so far because its vehicles have been modified missiles—but hundreds of millions may be spent in the '60's

by Paul Means

WASHINGTON—The nation's fledgling space program is creating a new market for the missile industry—a market for space vehicle support equipment.

How fast the market grows will depend entirely on the progress of the space program. Though only about $30 million was spent by NASA this year on new space support equipment, the amount spent per year could grow into the hundreds of millions during the next decade.

Space vehicle support equipment is the instruments and tools that test, move, set up, check out, launch, track and control the space vehicle. It does not necessarily remain on the ground. Space stations used for launching vehicles into deep space would be support equipment. So would the equipment needed to support space vehicles and their crews on the moon and other planets.

The market is curtailed presently because most space vehicles in use are modified missiles which use equipment already in existence. *Jupiter-C*, *Juno*, *Atlas-Able* and *Thor-Able* all use the support equipment developed for their missile prototypes. The only current space vehicle that was developed from the ground up as a space vehicle with its own equipment is *Vanguard*.

Many of the newer space vehicles, such as *Centaur* and *Vega*, are also adapted from missiles and will use existing equipment. *Scout*, operational next summer, will be the first space vehicle since *Vanguard* needing its own support equipment.

But as newer space vehicles come off the drawing board, the market will increase for space vehicle support equipment of a type that will hardly resemble missile support equipment.

The support equipment needs of space vehicles are radically different from those of missiles. A missile must be easily serviced, rapidly moved, and quickly implaced, fueled and fired. Space vehicles, on the other hand, are fired one at a time from the same launching pad at non-strategic bases, under clinical conditions, at unhurried, opportune times.

Support equipment designed for advanced space vehicles must be capable of moving large, heavy and fragile components, of handling the most toxic and radioactive fuels, of firing rockets developing millions of pounds of thrust, and of tracking, telemetering, and sending commands so complex as to be undreamed of in the military missile world.

Specific support needs of space vehicles are:

- **Tracking, telemetering and ground command stations**—as space vehicles achieve the capability of changing course or orbit upon signal, and of travelling millions of miles from earth, the need will arise for more powerful and more complex ground stations.

Estimated NASA-ARPA cost for such equipment during the next few years is from $50 million to $75 million per year.

Thirty million has already been spent for the east-west Minitrack fence used originally in the *Vanguard* program. Over $3 million has been allocated for a similar fence in Alaska, the northern United States, and Canada, to track satellites in polar orbits.

NASA plans to bolster its deep space tracking in the near future by constructing two more of the multi-million dollar Goldstone 85-foot parabolic dishes. And the demand for deep space tracking apparatus will increase as space vehicles achieve the capability of probing farther into space.

Man-in-space will place a heavy burden on industry to come up with the type of supporting ground electronic equipment that will keep him safe and in control of his vehicle. Original estimates for the Project *Mercury* tracking range is over $15 million, with $5,250,000 going for a tracking, communication and radar acquisition network in Southern Texas.

Further into the future, the electronic supporting equipment needed for space stations, and moon and planet launching bases should provide the electronics industry with a sizable market for years.

- **Test and launch equipment**—As missiles become smaller and more compact, space vehicle boosters will become larger and heavier. This places special requirements on the types of test stands and launch equipment that must be used.

Saturn, the first of the large space vehicle boosters, will be over 200 feet high and will weigh 580 tons at lift-off. To provide for its needs, a special 175-foot test tower is being built at ABMA, and a 305-foot self-propelled service stand will be built at the launching site.

Types of equipment this tower will need include fire protection facilities, personnel safety devices, heating and air conditioning systems, lightning protection, elevators, cranes, and generators.

These requirements give an idea of the immense and complex type of equipment needed to launch the large future space vehicles. The six million pound thrust cluster *Nova*, and space boosters still on the drawing board, will even be larger.

- **Check-out equipment**—Some of the newer propellants to be used in space vehicles, such as liquid hydrogen, and liquid flourine, are going to require exacting and safe check-out equipment. The problems of checking out boosters propelled by nuclear reactors, ion, plasma or photon energy, have hardly been approached.

- **Moving equipment**—How do you move a booster over 200 feet long and weighing hundreds of tons? Unless you dismantle the vehicle, and reassemble it at the launch area, you must devise some way of flying it, moving it across land, or floating it down rivers intact.

- **Man-in-space**—Before man occupies a space station, or installations on the moon and the other planets, a great deal of research must be done to establish what sort of support equipment he needs. Space stations and moon stations must be built on the ground that will match the rigors of space environment. Millions of dollars will be spent for research on this type of support equipment.

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Who Should Be Prime to Design-Build?

Big steel fabricators dispute role of missile makers in constructing rocket stands

by M/R Staff

WASHINGTON—Construction of a 2400-ton, 310-foot-high missile service gantry involves problems vastly different from those encountered by engineers in the design of bridges and conventional structures.

The $4-million tower being built for *Saturn's* 1.5 million-pound-thrust must be able to accommodate a 240-foot missile and provide for its safe servicing, checkout, and launch and for the comfort and convenience of the missile crews.

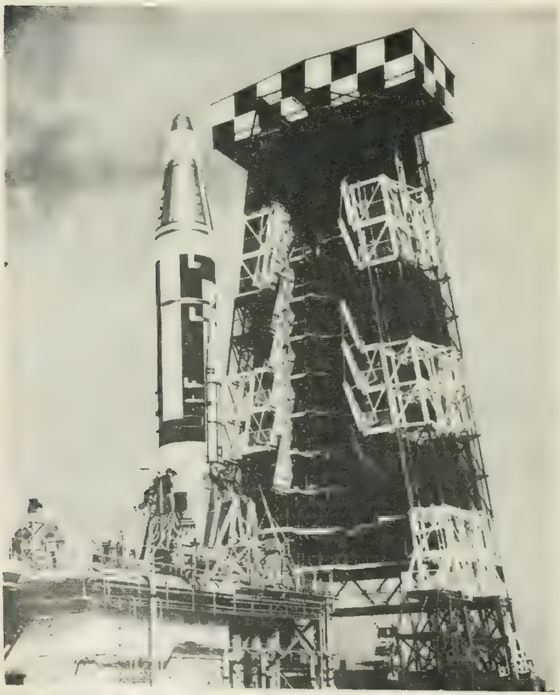
Such a structure is practically a city in itself. It contains its own power station, elevators, air-conditioning, fire-protection, intercom, water, air, hydraulic, and lighting facilities, complex operating controls, and lightning protection. And the entire structure must be "portable"—that is, be capable of being moved under its own power to a safe distance during launch.

There are two opposing schools as to who should be the prime contractor on the design and construction of such structures. One—typified by **Kaiser Steel**—holds that the design, fabrication, and erection of the basic structure and its mechanical components should be in the hands of firms with a long background in construction and heavy equipment fields.

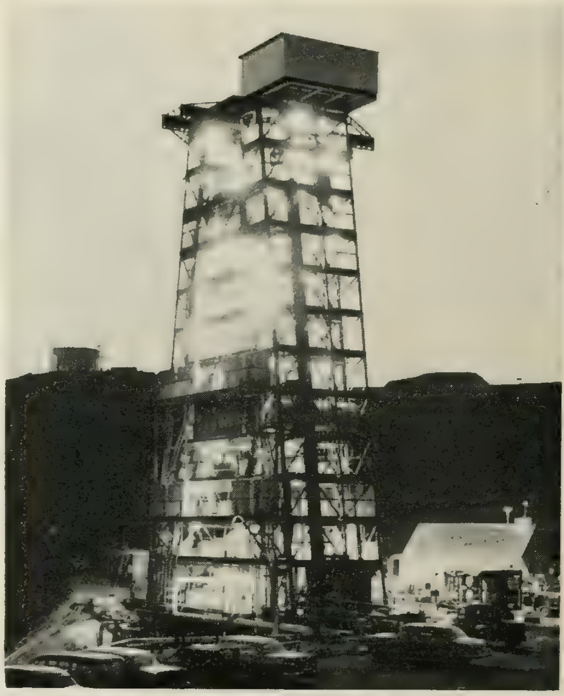
The construction firm feels that the missile contractor's participation should be limited to those areas and to the extent governed by functional requirements imposed on the service tower by the missile itself.

The other view is that the missile prime should have full cognizance and control over all support equipment, including the towers. They hold that the gantry is basically a simple steel structure whose fabrication and erection is straightforward and should be bid competitively and built from the engineering firm's designs and specifications.

• **Money keys procedure**—The steel fabricators in this young but thriving



FAMILIAR *Atlas* mobile tower is 135 feet high. It backs away to a safety area when the missile is ready for firing. Kaiser Steel designed and built the first model.



STATIONARY *Atlas* engine testing stand was Kaiser's first. They collaborated with Convair on its research and design. Convair controlled support in *Atlas* program.

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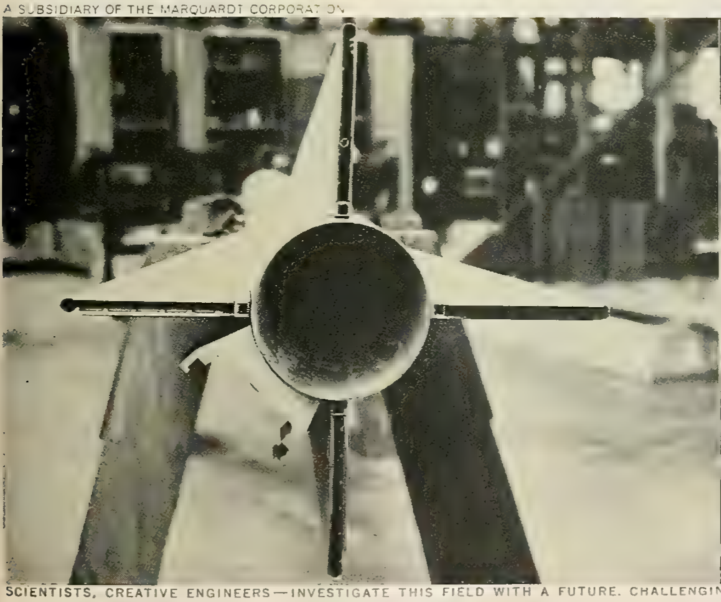

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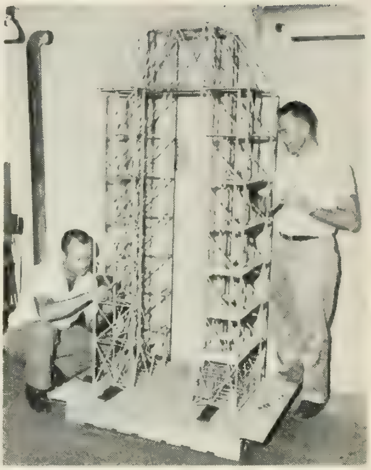
as usual, money talks . . .

Space Age industry counter that big test stands and gantrys are as tricky to build as missiles, and require a specialized engineering talent to cope with the never-ending stream of modifications. Says N. M. Schroeder, Kaiser support equipment project engineer, speedy incorporation of changes is most effectively accomplished "by the 'design-build' contractor working in close harmony with the missile designer."

Actually, procedure is determined by who has control of the money. In the case of the *Atlas* program, **Convair**, the missile prime, had control over the entire weapons system. They could, and did, award a design-build contract to Kaiser Steel for the Sycamore Canyon static test facility and two mobile service towers. Later, Convair awarded a contract for 14 of the towers—modified to allow for horizontal checkout—to **U.S. Steel**.

In most cases, however, responsibility for support construction for Army and Air Force missiles is held by Army Corps of Engineers. (Bureau of Yards and Docks has similar cognizance for the Navy.)

Government policy is that design and construction be handled by separate firms. Generally, a contract is let to design the structure to governmental specifications based on missile requirements. After the design has been approved, another contract is let for construction of the facility.



SCALE MODEL of *Saturn* tower. Kaiser engineers first built 80-inch model to study fabrication and operation.

This procedure, although sometimes ponderous, provides a check and balance. It also offers a measure of guarantee that all will be done according to Hoyle.

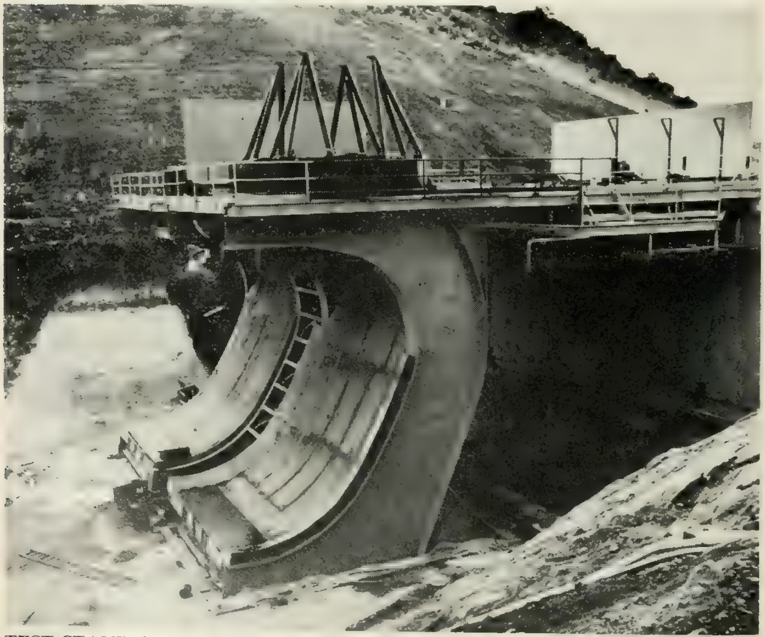
- **Objections raised**—Many in the industry feel, however, that the firm doing the design work can logically do a better job on the construction. In any case, the bulk of missile gantry work is done under Army Engineers procedures.

As in many other phases of missile development, some odd situations are sometimes created in the procurement jungle. As an example, **Aerojet-General** was awarded contracts to construct two 1.5 million-pound-thrust test stands at Edwards AFB. In their capacity as an A&E firm, this would arouse no particular question.

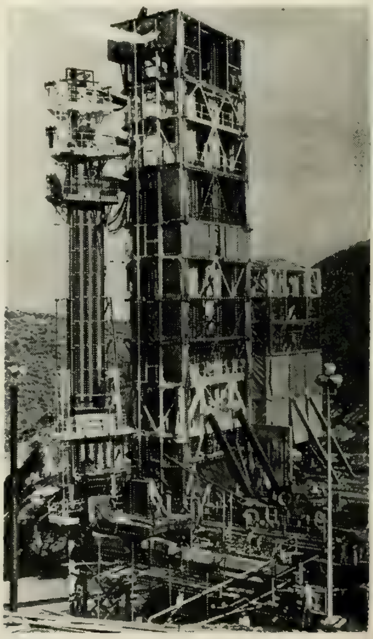
However, **North American**, the prime, objected strenuously since Aerojet-General is one of their main competitors in the propulsion field. According to reports, other A&E companies also objected.

It appears likely that most of the future test and launching gantries will be built under the established procedures of the Corps of Engineers—especially since procurement policies are getting away from the weapon system concept which gave the prime contractor cognizance over the entire missile system.

Much can be said for both sides in the controversy, but the primary objective, of course, is that our missile and space programs have the support structures equal to their job when and where they are needed.



TEST STAND for *Titan* is designed to deflect the flames and thrust of a multimillion horsepower motor. Many construction companies feel that equipment like this should be built and erected largely by firms with construction background.



TOWER structure consists of 104-foot missile erection and service tower plus 52-foot tower for second stage.

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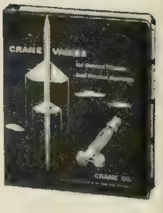

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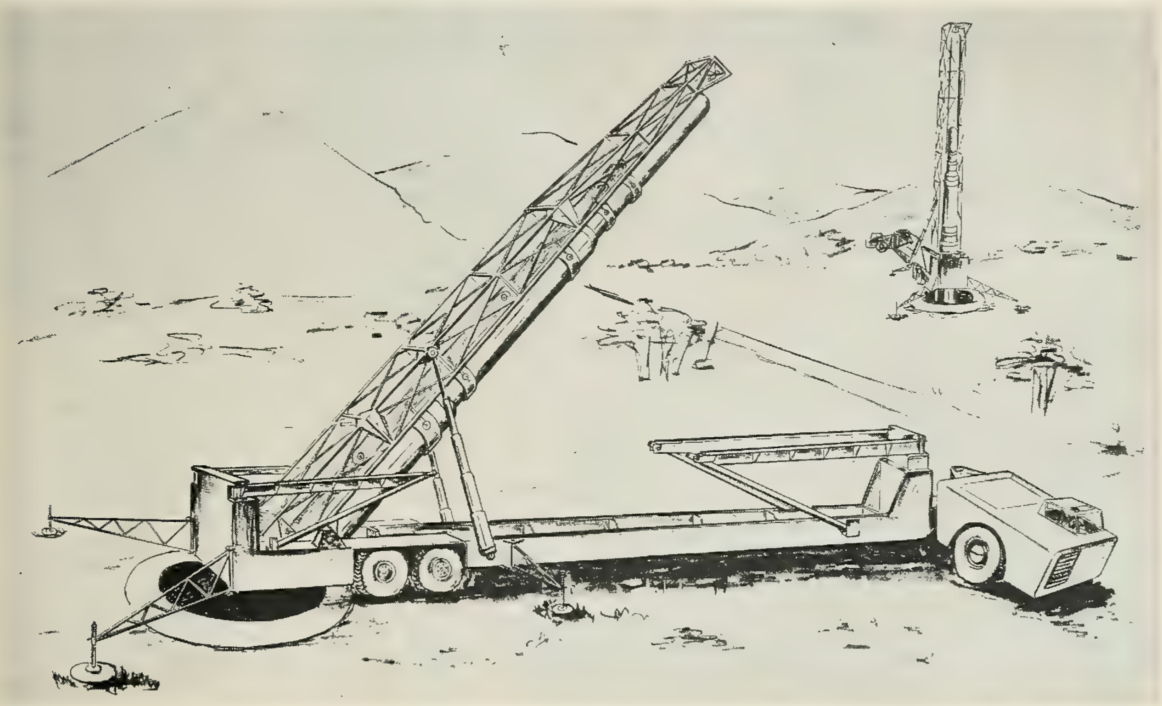
Minuteman Handling Must Be Delicate



by Jay Holmes

WASHINGTON—Handling of the **Boeing** *Minuteman,* America's flexible intercontinental missile, will be a major challenge to support equipment makers.

The finely-balanced and structured weapon, with its sensitive guidance gear and solid-propellant grain, must be able to move over rough terrain in remote areas or on trains to fulfill its mission of "mobile" instant retaliation. Furthermore, it must be taken out of its hard base at intervals for checking and recycling of propellant.

The missile, due to be operational in 1962, will be transported in ready-to-fire condition. This is to provide maximum readiness, since only the thermonuclear warhead will be installed at the underground launch site. The *Minuteman* concept of widely dispersed launch facilities, most of them ready to fire at any given time, will provide assurance that at least some of our retaliatory weapons will escape destruction even after a surprise attack.

The lightweight skin of the rocket case is a major difficulty in transporting *Minuteman.* The skin, just strong enough to hold the combustion pressure, must not even be scratched, lest it be weakened by notch sensitivity. Bending loads must not be imposed. Temperature must be rigidly controlled.

To deal with this dilemma, **General Electric** proposes a missile carrier and loader powered by direct current electric motors. A gasoline engine generator would supply current. Electric motors have no gears to shift while the carrier is accelerating or decelerating, and while the hoist is transferring the missile to and from the silo. There are no sudden jars.

In a further effort to keep the ride smooth, all wheels will be equipped with hydraulically operated brakes as a supplement to dynamic braking. And on either side of the carrier's pivot center, a trunion provides three-point support that eliminates any twisting or bending while the missile is raised or lowered into position.

The versatility of the electrical system allows performance to be altered to suit any changing requirements and to furnish power for auxiliaries. One of these needs is temperature control, provided by a combination refrigerator-heating plant with a blower.

One 70-foot carrier has already been produced by **Utility Trailers,** Los Angeles, for *Minuteman.*

Boeing, associate general contractor for assembly and test of *Minuteman,* and a rocket engine company probably would operate the assembly and recycling facilities. The Air Force is reported to be studying sites in Nebraska, Kansas and Iowa, among others, for their location. Although it is presumed that the launching bases will be relatively close to the assembly facilities, their locations will be secret.

It will be fairly easy to hide launch facilities because they will be much simpler and smaller than those for *Atlas* and *Titan,* the liquid-fueled ICBM's. *Minuteman,* stored in a camouflaged silo, will be launched by remote control from an inconspicuous building nearby. Personnel and ground support facilities will be few.

Autonetics Division of North American Aviation has the *Minuteman* guidance contract. **Avco** is making the reentry nose cone. **Thiokol** is developing the first-stage propulsion, with limited backup by **Aerojet-General.** Aerojet and Thiokol have second-stage development programs stressing different technological approaches. Aerojet is working on the third stage with **Hercules Powder Co.** developing a parallel program stressing a different approach.

Last week, **Data-Control Systems Inc.** announced receipt of a $750,000 contract from Boeing to develop the FM/FM ground station telemetry system for the *Minuteman* test program.

In Fiscal Year 1960 alone . . .

$550 Million for ICBM Facilities

Here's an authoritive account of the complex and constantly changing requirements of the nation's most massive design and construction program.

by Lt. Col.
Charles B. Alexander, Jr., USAF
and Fred E. Ressegieu

LOS ANGELES—From its Ballistic Missile Division (ARDC) here, the Air Force supervises and directs the largest design and construction program in the United States today—the preparation of bases and launch facilities for the country's rapidly increasing arsenal of intercontinental ballistic missiles.

In the fiscal year just concluded, the Air Force committed approximately $200 million to the program for construction of facilities, making a total of $480 million to date. The FY 1960 budget passed by Congress includes a figure of approximately $550 million for ballistic missile facilities. BMD handles directly the design of all these facilities; the Army's Corps of Engineers is BMD's principal constructing agency.

Because it is vital that bases be ready as soon as the ICBM's are available, their design and construction is being accomplished concurrently with development of the missile. Growth and change are inevitable as the missiles approach operational status, and changes in the facilities must keep pace during both design and construction. Close control and integration by BMD makes this possible.

Col. William E. Leonhard is BMD's Deputy Commander for Installations. His organization manages the design of test, training and operational facilities for the ballistic missile program, using selected architect-engineers for the actual design.

BMD's responsibility continues during the construction phase. Changed requirements must still be coordinated with the missile contractors and the facility designer and incorporated into the launch buildings during construction. Col. Leonhard accomplishes this through his own field offices at each construction site.

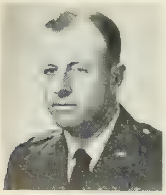
Construction of missile launch facilities is now under way at eleven Air Force bases in the United States. The Department of Defense appropriations bill for 1960 provides increased funds for speedup of missile programs, specifically for *Atlas* and *Minuteman.*

After receipt of a design assignment, the Architect-Engineer's first concern is to accumulate the information necessary for him to proceed. This includes design criteria from the missile designer, design and operational criteria from the Air Force, construction agency design standards, and specific information pertaining to the site, such as soils, topographic and real estate data.

• **Complexities**—Most complex of these by far is the first—the design criteria from the missile designer. In designing missile facilities, the construction engineer finds himself involved in an engineering problem of new dimensions. Inherently complex, the missile and supporting equipment must be sheltered in a facility designed to withstand overpressures, ground shock, and radiation from nuclear attack.

Understandably, the criteria from the missile designer is provided in considerable detail. It consists of design documents accompanied by drawings specifying critical dimensions, clearances, and arrangement, as well as power and other utility requirements, temperature, humidity, shock and similar physical limitations. Interfaces between the facility and the missile are specified or suggested. The detailed requirements of propellant storage, handling, and loading are particularly critical. All of the necessary information to assure that the facility will properly support the weapon system is supplied to the A-E after check and approved by the Air Force.

Criteria originating with the Air Force include those of the Strategic Air Command based on operational needs. Design specifications assure incorporation of the latest technical improvements, by-products of studies and research conducted by BMD as well as their experience with other missile systems. Of considerable importance are the "austerity" criteria which assure that completed designs contain no frills and meet minimum essential standards for the use intended.



ALEXANDER

RESSEGIEU

About the Authors

Colonel Alexander is Assistant for Technical Requirements, WS-107A-1, Facilities Division, AF Ballistic Missile Division, ARDC. He is responsible for validation, correlation and approval of these requirements for launching and support of the Atlas and integration of these requirements into design criteria. A native of Macon, Ga., and a graduate of Macon University, he was an Air Force intelligence officer in Europe in World War II.

Mr. Ressegieu is Manager of Defense Projects, Power and Industrial Division, Bechtel Corporation. He is a graduate of West Point and has an AM in civil engineering from Cornell. He retired from the Army with the rank of colonel after 20 years' experience including service as District Engineer in St. Louis. From 1954 through 1957, he was Chief of the Plans and Programs Division in the Office of the Army Chief of Research and Development. Since joining Bechtel in 1958, he has been involved in ICBM facilities designing.

NEW DRAWING by a Bechtel Corp. artist shows blast-off of now operational *Atlas* from a hardened launching site, still in construction stage.

Information pertaining to the site is received from SAC, A-E studies and the construction agency concerned through arrangements made by BMD.

• **Constant change**—Few of the criteria listed above are static; arrangements must be made for orderly incorporation throughout the design of continually changing requirements. Most critical and complex, and most subject to change, are those criteria provided by the missile system contractor. While changes can be effected by formal changes to the original criteria document, transmitted through BMD, more often than not the urgency of time will require a short cut.

During a major design program, representatives of the Architect-Engineer may be physically located at the missile system contractor's plant, and representatives of the missile contractor similarly stationed at the A-E's design office. Through this close technical liaison, changes in the missile system are immediately known to the facility designer and their impact on the facility design can be calculated. Any required changes are of course subject to BMD approval.

Panels of experts are available for discussion and consultation on specific areas of classified information such as effects of nuclear weapons, blast waves, radiation, ground shock.

Systems technical direction and coordination of the many technical requirements of integration of the several weapon systems is handled by Space Technology Laboratories (STL) acting as agent for BMD.

• **Conception and review**—In the design of missile launching facilities one of the first steps is delineating the basic concept to be followed.

The Architect-Engineer prepares a concept based upon the total criteria and presents it to BMD, usually using a series of charts which show general arrangement of equipment and buildings in plan and section views as well as proposed treatment of some of the more unusual problems.

At this presentation, BMD, SAC, STL, and other key groups can evaluate the concept and direct changes if required prior to approval, so that detailed design can proceed.

After approval of the concept, the Architect-Engineer prepares the preliminary design, which includes drawings, outline specifications of equipment and materials, and engineering calculation. This is thoroughly reviewed by AFBMD, an engineering review conference is held, and BMD directs any changes to be incorporated into the final design. Further conferences are held with SAC, the designers of the missile, and the designers of its support equipment; the design proceeds to its final phase embodying the requirements for operation of the missile and of its supporting components.

Final design of the facility is submitted and again reviewed. Every detail is gone over with a fine-tooth comb; new developments are incorporated. Design drawings and specifications are then modified and passed to the constructing agency.

Design work, however, does not come to a halt with the award of a construction contract; any change which occurs during development of the missile or its support equipment must be reflected in design of the facility. Major changes affecting the construction contract are handled by change orders to the contractor. Other changes or clarifications of the drawings and specifications are handled by BMD's field representative, who continuously checks on construction to see that it is completed on schedule and in strict accordance with the design, including such changes as may be developed in the field or in the change orders.

• **Tough requirements**—The requisites of a good Architect-Engineer for missile facility design work are stringent.

The work includes structural, architectural, civil, electrical, and mechanical engineering and drafting and preparation of specifications. While much of the work is like that performed on any large and difficult engineering project, there are important differences involving special skills and organizational flexibility and adaptability.

Most of the designs must protect men and equipment against nuclear blast and radiation and still allow the bird to be launched on command. Protection of structures, men, and equipment from the tremendous ground shock requires designers with the best possible background in such problems.

Since resistance to a nuclear attack necessitates underground design, problems in soil mechanics become extremely critical. Ground water is a problem in some areas; in others there is the opposite problem of obtaining an adequate electrical grounding grid and a suitable source of water.

Particular skills are required for designing cryogenic systems. Special equipment and design are required to meet their unique problems. The techniques of normal temperature piping, valving, control, and liquid transfer are inadequate; even materials of construction are different. Carbon steel, for example, is brittle at these low temperatures and cannot be used for pipe, valves, pumps, or vessels.

Schedules are tight and become even tighter as design progresses. A finished design of one part of the facility may be nullified overnight by developments in the weapon or its components and must be redesigned. To meet the schedules, checking must proceed continuously and simultaneously with design; flexibility is the keynote. Coordination of all phases must proceed rapidly, with constant intercommunication among all government and civilian groups.

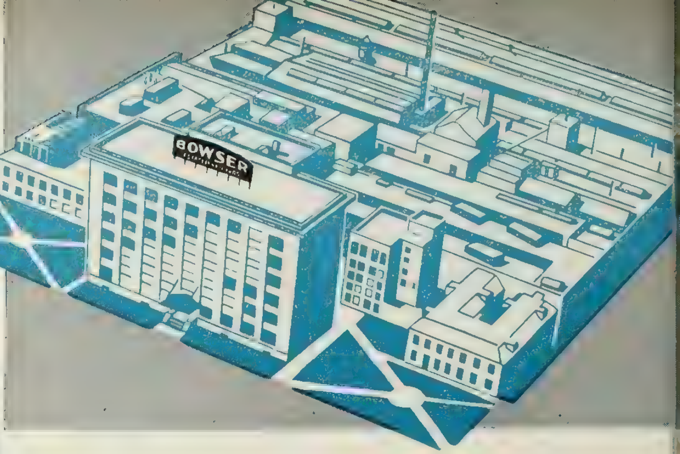
• **Nine at a time**—An operational squadron for the *Atlas* ICBM can simultaneously fire nine missiles—grouped three to a site or totally dispersed, with only one to a site.

Training bases are built to be as nearly like operational sites as possible, insofar as actual equipment and arrangement are concerned. The term "Hollywood Hard" has been coined to describe these installations which simulate the "hard" operational bases, the main differences being that the hard bases are underground and have more massive concrete structures.

Each missile is housed in a Launch and Service Building. This building contains, in addition to the missile, all the auxiliary equipment required to raise and fuel the missile, arm it, and check and set its guidance system. The whole

(continued on page 76)

FROM *Concept* TO *Application*



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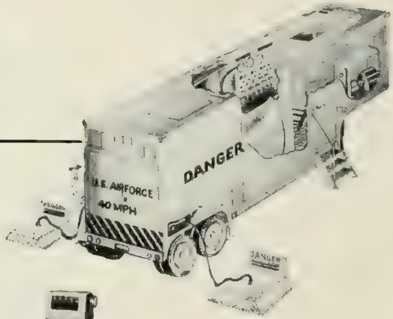

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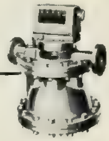

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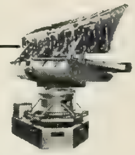

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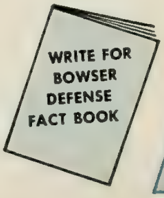

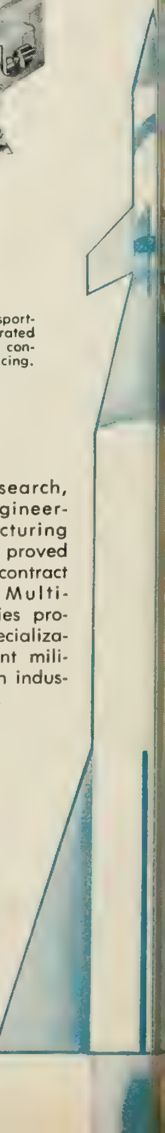

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Packaging Influences MSE Concepts

How the growing utilization of 'packs' is boosting missile/space reliability and maintenance and cutting costs

by Edsel F. Moffitt

Akron, Ohio—The most obvious consideration in the design of missile support equipment (MSE) or a support system is that the functional requirements of the missile, aircraft or other vehicle be met.

These functions are often defined through specifications which set forth in definite terms requirements that must be met in regard to a specific operational capability. However, there are other, less obvious considerations that have a major influence on design.

Included in this category are factors such as reliability and ease of maintenance which are often dealt with in comparatively general terms in specifications. To this list should also be added ease of logistic support and versatility—adaptability to use in multiple applications or several programs. Versatility borders on and is closely associated with standardization, still another consideration in design and development of missile support systems or components.

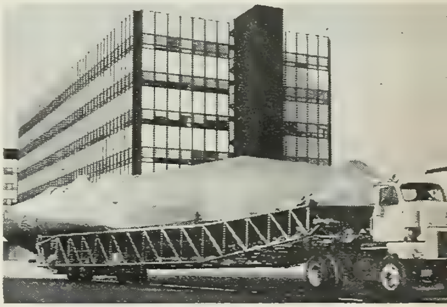
- **Packaging is basic**—These considerations—operational capability, reliability, maintenance, logistics, versatality, and standardization—are obtained or lost to some degree through the factor of "packaging": that is, how the system, sub-system, or major component is put together or assembled.

Packaging is a basic element in working out a system. In some cases it may very well *be* the system. Generally, however, packaging means assembling into a functional entity various detail equipments or components for performing related or complementary functions. Examples of this type of package might be vehicles such as trucks, trailers, track vehicles. A semitrailer in which is installed telemetry, communication, or test equipment illustrates the idea of packaging. Other examples are transportable housings or shelters.

The criteria for packages, or "packs," of this nature may also be applied in a sub-level; for example, a console of equipment installed in a trailer or shelter. Further application may be made even to the level of "black boxes" installed in a console. It is obvious, however, that greater benefits are obtained in the first level, where the greatest quantity of material is involved.

Missile launching systems, communication systems, command control, and tracking systems are candidates for the application for packaging technique. It can also be applied to servicing equipment for missiles, rockets, VTOL aircraft and the more conventional aircraft. A notable example of its use is the *Mace* ground support system produced by **Goodyear Aircraft Corporation.** This system utilizes a building block principle; the equipment is packaged into "packs," and when various combinations of these "packs" are assembled the required operations of the missile from assembly, through transport and checkout, to launch can be performed.

What is obtained by packaging? What is gained by the systems engineer in utilizing the packaging technique or basing a missile system on a type of building block organization? The advantages discussed below might be considered as criteria for developing missile support equipment. (They are not necessarily listed in order of importance.)



PACKAGED *Atlas* **ICBM leaves Convair plant at San Diego on specially built trailer for delivery to Cape Canaveral.**

- **Versatility**—The capability of applying an item of equipment to various systems or of having application to various functions in a given system may be illustrated by communication equipment installed in a transportable shelter. The basic shelter itself can be a further example; in the case of the *Mace* system the same basic shelter is used in several applications.

- **Transportability**—Packaging into units also provides ease of transportability, a boom to the military because it facilitates movement required by tactical and training operations.

- **Flexibility**—A packaged system also gives flexibility—the capability of composing arrangements of equipment in various theaters of operation to meet various tactical conditions. This in part is accomplished by the building block principle.

- **Maintenance**—Maintenance of a support system in the field is eased through application of packaging. The maintenance problem is reduced to a simple matter of replacing component packages whenever failure occurs. Various levels of maintenance may be established—a complete shelter or trailer may be replaced, a change of cabinet made, or a black box changed in a cabinet. As a result, down time is reduced, and fewer and less skilled personnel are necessary.

Sending "packs" back to the depot permits factory level of service and/or overhaul, providing a high level of skill along with more tools and facilities. Usually this means field equipment is in better condition; frequently it also saves money.

In several missile systems a Contractor Maintenance Service is provided

About the Author

Since his graduation from the University of Louisville in 1946 with a BS in Mechanical Engineering, Edsel F. Moffitt has spent more than 12 years in the design of various structural and mechanical components or support equipment for aircraft and missiles, as well as other lightweight structures such as radar antennas. During the past six years he has worked in the area of missile support equipment design at Goodyear Aircraft Corp.

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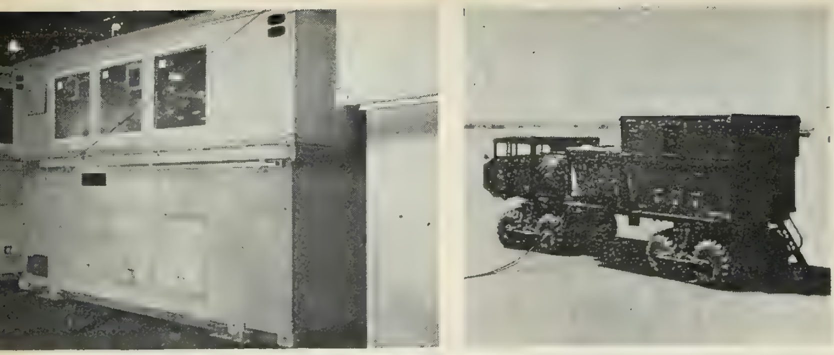


EXAMPLE OF packaging equipment into housings is typical pack, at left, built by Goodyear Aircraft for *Mace* program. At right, packs mounted on all-purpose truck.

by the prime equipment producer or other contractor to the military organization. Through this arrangement the contractor in effect provides a depot maintenance capability with the backing of a manufacturing organization. As an illustration, consider as a pack a railroad car launcher for a ballistic missile. For maintenance the car may be replaced, routed directly back to the depot or factory, serviced or repaired, and placed in usable supply again. The result—reduced field down time and a higher level of maintenance service.

- **Supply**—Packaging permits flexibility of supply; units can be easily transported, stored and relocated if necessary. Instead of inventorying and stocking a group of sub-assemblies, the user relies on a specific operational entity, supplied in a package. And equipment of this type is ready to operate with a minimum of servicing upon reaching operational site; no installation is required and no time-consuming check out is necessary. Again the resultant savings are apparent in the reduction of personnel and skill levels required at the operational site. And there's reduction in down time of a particular function or system.

"Packs" facilitate any central supply systems that might be established, such as that now incorporated in the *Mace* program. Here the Missile Automatic Supply Technique (MAST) uses an electronic computer tranceiver in global hook-up to keep tabs on all components for the *Mace* system. Computers instantly figure inventories and issue signals to warehouse points or manufacturers in seconds, providing whatever orders are necessary for production and/or shipment of needed components. A supply system of this nature, coupled by air transport with the capability of quick setup on the operational site, provides a short supply time, from material source to operation, not heretofore obtainable.

The advent of widespread use of air transport has brought a new approach to maintenance and supply; the time required to transport from using organization to depot maintenance point or supply point and back to using organization is no longer a controlling factor in the cycle. And packaging simplifies air transportability and thereby further reduces the time cycle.

It should be noted that packaging for operational advantages also provides in effect a shipping container; boxing, crating or much of the other processing for shipping is eliminated. In the case of relatively small missiles, consideration has been given to shipping in a container which may then be used as the launcher.

- **Erection**—Savings of a packaged system are reflected not only in operational maintenance and supply, but in the simplified initial construction or setting up of the site. Manpower requirements over and above normal operating personnel are reduced or eliminated. This is particularly significant because many operational sites are located, or are subject to relocation, in remote corners of the world. Again, the reduction of personnel reduces major problem of logistics.

- **Reliability**—Packaging will tend to enhance reliability, since installation and checkout will be conducted at the factory where conditions are more favorable for applying reliability techniques. Reliability of detail components will increase because the equipment may be installed and completely checked out in its operating environment. This is particularly significant with the installation of electronic equipment into shelters or van trailers. And reliability in this case will also be aided by the fact the equipment may be shock-mounted to reduce the possibility of damage in shipping or handling.

- **Types of installations**—Several types of operating installation or complex may profit from adoption of a packaging concept. Fixed installations obviously will benefit from the concept's flexibility, simplified maintenance, ease of supply, ease of erection and increased reliability. Ease of installing, removing, or servicing the missile or other flight vehicle is also of importance to a fixed installation.

In an installation of the type planned for the *Minuteman* missile, these factors would save both time and funds; with a complex of a great number of missiles, the ease of these operations results in great cost saving. This of course applies to the servicing of both the missile and the support equipment. Even more importance may be attached to the time factor when missiles such as *Minuteman* must be kept on an "alert status." Packaged equipment also will enhance standardization of equipments and components for use in various installations or locations.

Semi-fixed installations can be obtained through the packaging technique without the investment demanded by a completely fixed installation. A missile Operations Center "pack" similar to that used in the *Mace* program, for example, will provide facilities for control of an operation without the expense of a permanent concrete and steel structure. And much of the investment in a site using packaged components can be salvaged when the site is abandoned. This situation is noticeable in a satellite program, such as Project *Mercury*, where tracking and communications equipment may be set up in far flung locations. Upon completion of the program, the equipment can be salvaged; at any time during the program, the site may readily be relocated. Furthermore, "packs" permit operation in relatively unprepared terrain or geographical environment; this results in savings in time and money.

Mobile systems of course benefit most from the packaging concept. All the above noted advantages are applicable to the mobile system.

Shipboard installations also reap the benefits of the package concept. Often the same equipment packages can be used interchangeably on both ship or shore; but even though the installation cannot be identical or interchangeable, packaging has merit on a shipboard installation. It tends again to reduce installation and checkout time, reduce skill levels required on board, and ease logistics. Transfer at sea may be simplified by transferring a complete package rather than a quantity of detail items of equipment.

- **Concept application**—Although this discussion primarily relates to missile support, it is interesting to note other areas where packaging concepts have been applied. Particularly is this apparent in the vehicle to be supported itself. We see the advent of packaged fuels; missile stages and/or sections are packages; much thought is presently being given to escape capsules or packages; commercial application of the concept is being made in the aircraft industry—a notable example is the DC-3 baggage handling system.

This discussion is based on equipment considerations only and does not take into account operational requirements such as mission. Operational requirements may override or overrule certain of these equipment considerations, but the latter generally tend to support or complement the former.

Missile support equipment must be considered or designed along with the flight vehicle or overall system, if maximum realization of the benefits of packaging are to be obtained, MSE development must start early in the system conception. The close relationship between MSE and the missile can be seen in the case of automatic test equipment for checking out of the guidance system. The *Atlas* Transporter developed by **Goodyear Aircraft Corporation** is an additional example of the influence the missile characteristics had on the handling equipment.

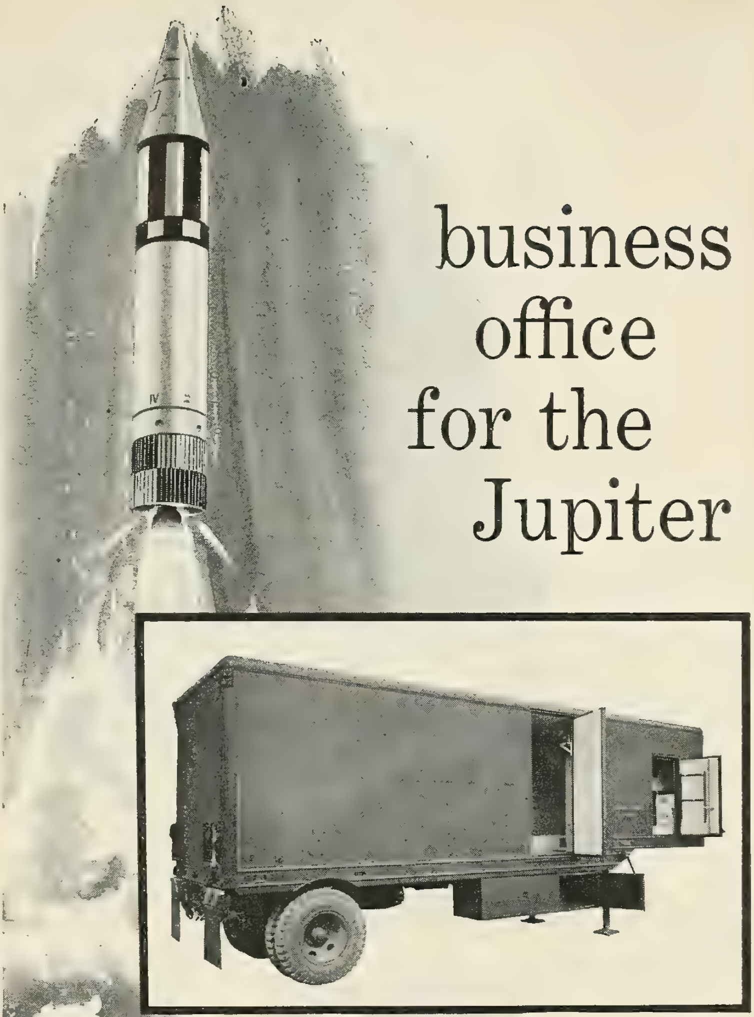
Support equipment is also influenced by training requirements and use. Experience has shown that equipment often gets its heaviest use in training and not in operation. Therefore, life consideration should be based in part on training. Also, the configuration of the equipment might well be affected by training requirements. The packaging concept would receive greater emphasis in cases where training could not be conducted at the same site as tactical operations, for instance, a case in which troops and equipment had to leave some heavily populated area and train at an established or designated missile range.

Costs naturally are a major factor in designing MSE; one way of reducing them is through mass production techniques. These techniques are difficult to realize in a field where quantity requirements for specific items are relatively low; nonetheless, they are goals to strive for.

One way to progress here is development of custom equipment by use of standardized (off shelf) components packaged into sub-packages.

The most notable illustration of this concept is the automobile industry, where the basic automobile is produced in several series such as standard, deluxe and custom, but all are variations of the same basic product.

But what about the size of the coming rockets? Will this not defeat the trend toward packaging? The answer rests in the fact that the limiting factor in moving to larger and larger items has been the "state of the art." As the "state of the art" moves forward so does the capability of performing with larger equipments.



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Automatic Test Equipment Solves Logistic Nightmare

With a potential market of nearly one-half billion dollars, this facet of support equipment has an assured future . . .

by George A. Peck

ROCHESTER, N.Y.—Out of the military requirements of the missile industry has grown a new product with a tremendous future—Universal Automatic Test Equipment. In an industry growing like Topsy, its early evolution was predestined as the only solution to a profusion of complex and sensitive test devices.

Due to the multitude of missile and aircraft weapon systems, the variety and form of specialized test equipment has become a logistic nightmare. Add to this the continuing need for highly skilled technicians to maintain this gear, hindered by a rapid turnover rate in the Armed Forces, and you have an economic problem of vast proportions.

Over $1.5 billion of defense money will be spent on ground support equipment for missiles and aircraft in fiscal 1960. Of this amount, from 10% to 30% of every program will be spent on electronic MSE, creating a potential market of $150 million to $450 million for this type of equipment.

The military thus faces the continuing need to initiate economies by (1) simplifying logistics, (2) reducing the necessary skill levels, (3) reducing the sheer numbers of operators, and (4) increasing reliability.

The most logical answer to this problem is standardized test equipment, automatically self-checking with built-in fault location capabilities, and flexible enough to be adapted with a minimum amount of engineering development to any existing or projected weapon systems. The logic behind this concept is readily apparent:

- **Standardized test equipment** is necessary to reduce the logistics problem of replacement parts supply. A reduction in the variety of such gear also simplifies the task of training operators. Besides, the flexibility gained cuts the engineering costs for new weapon systems and permits faster delivery of operational equipment.

- **Automation** allows for greater speed of checkout. In one typical operation a 12-hour manual testing procedure was reduced to less than 5 minutes by automatic means—a reduction ratio of 150 to 1 in operational time. An additional advantage exists in that machines do not become fatigued, bored, or try to cut corners. Therefore, testing reliability is greatly enhanced.

- **Self-checking** of the equipment assures (1) that these checks will be made and (2) that no testing time will be wasted by the use of a faulty tester. This increases reliability and establishes a higher confidence level in systems marked for operational use.

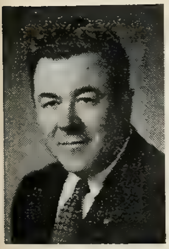
- **Fault location** techniques built into the tester lower the skill levels necessary for maintenance technicians. The capability may be utilized to troubleshoot both the tester and the system under test or either one, depending upon the system complexity.

- **Flexibility,** as used here, depends upon the amount of standardization feasible. Considering a basic controller-programmer as the truly universal test system, flexibility means that by the addition of adaptor modules providing unique stimuli to the systems under test, the basic unit might be used for testing a wide variety of weapon systems. Thus, by merely changing tape programs and switching adaptor modules a number of systems may be checked out by the same basic unit at the same location.

- **Configurations**—There are many forms which automatic test equipment may take, but the most logical of these is the modular, or "building-block," form. The major advantage of this configuration is potential growth capacity. By simply adding drawers of circuitry, capabilities can be extended to provide for greater needs in data handling and to include tests completely new in nature.

The basic comparator-programmer circuits may be standardized to the point where libraries of such elementary designs are established. Mounting these circuits on standard-sized printed

About the Author



George A. Peck is vice president and general manager of the Electronics Division of the Stromberg-Carlson Division of General Dynamics Corporation.

He was graduated from Clarkson College of Technology with a BS in Chemical Engineering in 1937. He joined Stromberg-Carlson in 1942 as engineer-in-charge of the Materials Laboratory. For a short time in 1951, he was on leave from Stromberg-Carlson, serving as vice president in Charge of Manufacturing of Standard Cable Corporation, Chickasha, Oklahoma. He returned to Stromberg-Carlson as production manager of the Radio-Television Division, and continued in that capacity until August, 1955, when he was appointed vice president—manufacturing. In January, 1957, he was advanced to his present position.

family of generators wanted . . .

circuit cards will provide rapid replacement parts which may easily be reduced in value to the class of "throw-away" items.

The use of completely solid-state, transistorized circuitry provides greater ease of packaging, better accessibility for maintenance, and smaller size and weight. The use of semiconductors also increases reliability and the ability to withstand changing environmental conditions.

Miniaturization to micromodules or the use of cryogenics is probably not necessary and far too expensive in the present state-of-the-art. Besides, these techniques will not as yet meet military specifications.

Standard programming codes are being devised which are compatible with the variety of available read-in and read-out methods in use today. These codes are adaptable to fast, simple preparation techniques by technicians of low skill levels.

• **Environmental conditions**—The physical configuration and complexity of automatic test equipment today is largely determined by where it is used. For instance, use on the flight line calls for mobile, van-mounted gear; fixing pads require operations—center blockhouses; depots need bench-mounted racks; and factories call for production line settings.

In the near future, the intermediate echelons will develop a need for integrated and highly mobilized units for field usage. These will take the shape of trailers and smaller, self-propelled vans. Whatever the use, flexibility in packaging to meet a variety of environmental and operational conditions is a prime requirement.

Test equipment built in the past has had to comply to such specifications as MIL-T-945A, Mil-T-5148B and, currently, to the more stringent Mil-T-21200. These are still rigid enough to assure capability of the equipment during nuclear attack. However, there are few, if any, automatic test equipment units in the field today which meet fully the environmental requirements of these specifications. More work is certainly necessary along these lines.

• **Current problem areas**—The most pressing problem of automatic test equipment design, paradoxically, is not concerned with the tester itself, but with the system it must test. Very often, weapon systems are designed and built before any thought has been given to testing them, so that adequate test points are totally lacking. Waiting until the last minute to procure test equipment then calls for a crash program to make the system operational.

The necessity for proper test points usually calls for system modifications, which not only slows down the program, but also often has a degrading effect on performance. Then too, limited design time on the tester necessarily deters those engineers from putting forth their best possible efforts. The biggest penalty paid, however, is the lost chance to design fault isolation techniques into the integrated system and, thus, the need for much more exotic adaptor modules to achieve this capability.

The available test point situation is not quite as bad with newer equipments as with the old. System designers are now aware of the problem and are changing their philosophy, but old equipment in use is virtually inaccessible by automatic methods.

Adaptor design is also becoming more sophisticated as military demands for standardization are now being extended to this area. One of the prime requirements today is for a universal programmable stimulus generator.

At first glance, it would seem rather ridiculous even to attempt to build a generator ranging across the spectrum from DC to cosmic frequencies. Upon investigation, however, it becomes apparent that each requirement actually calls for a fairly narrow range of frequencies.

Therefore, what the Military really seeks is a family of such programmable stimulus generators, each member representing a small segment of the spectrum, programmable to a series of specific frequencies. Even these aren't devised overnight, but work is presently well along in providing these production-unit adaptor modules.

Never absent are the problems of time and money. Research and development absorb huge quantities of both, but are of prime necessity. However, the pressures of military needs and competitive advantages sometimes stifle the use of advanced techniques throughout the industry. The limited use of existing, highly reliable, solid-state test equipment at present is a good example.

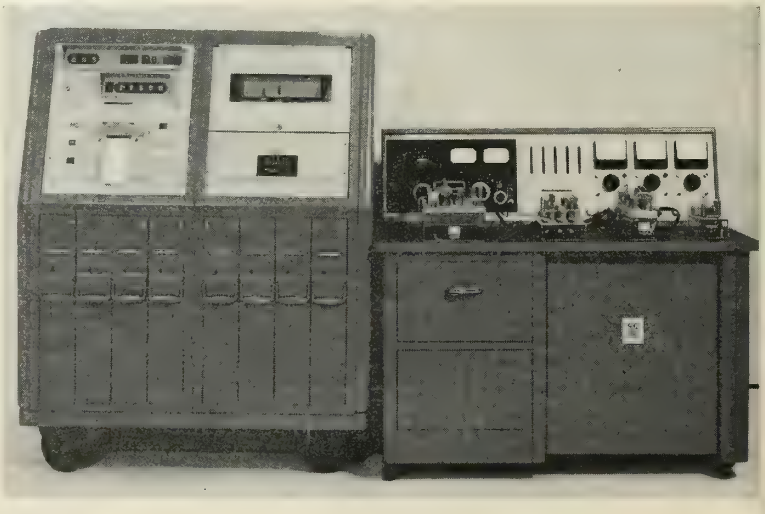
• **Limitations**—The potential of automatic test equipment is practically limitless. However, there is always the question of when it is *feasible* to use automatic test equipment. It is then a question of economic limitations, not engineering limitations.

Thus, the restrictions are basically those of time and money. Automatic test equipment must be utilized for checking out complete systems if it is to be used economically. Even depot use doesn't pay unless the system is extremely complex or testing encompasses production quantities.

Modification of the unit under test

Stromberg-Carlson's SCATE

TYPICAL OF many existing advanced automatic checkout systems is Stromberg-Carlson's SCATE. It is completely solid-state and modularly constructed for flexibility in adaptation. Stromberg-Carlson recently received a $500,000 contract extension from Bell Telephone Laboratories to adapt SCATE for testing the complex *Nike-Zeus* guidance system.



is not a limitation except to the extent that this would affect the adaptor modules. Punched tape permits easy revision of the prescribed limits and test procedures. Magnetic tape poses somewhat more of a problem, due to bit density, but is still not a major difficulty.

Operational speed sometimes presents a problem. The biggest limiting factor of speed is the operation sequence of the unit under test. Read-in and read-out modules often are not compatible, but faster methods are currently available at the cost of further system sophistication.

Physical problems limiting operation speed are largely those of switching techniques. Besides the sheer bulk of numbers of test points which often must be monitored, some type of electromechanical switching is currently the basic method used. This means is much too slow and inefficient.

In the more advanced forms of automatic test equipment, this has been replaced by a transistorized, solid-state switching matrix. Further research and development is also being carried on along these lines to offer a more complete solution.

• **The cost picture**—The price of automatic test equipment at first glance appears expensive. Spending $75,000 to $100,000 for a basic unit and another $50,000 to $200,000 for the appropriate adaptors uses up a million-dollar procurement budget fairly fast. However, the four or five test systems this will provide not only solve more than their share of problems faster, but will also be available as basic units for the next test system requirement that weapon developments bring.

Thus, the universality of the equipment spreads depreciation over a longer period. In essence then, to the savings in time, training, manpower and reliability, we also may add the savings of continued value through adaptability. Because of its flexible design, obsolescence losses may be diminished by the simple replacement of redesigned modules.

A trend is developing for the use of automatic test equipment in other industries besides missiles and aircraft MSE. Such areas as communications systems, data handling networks and ground radar station centers are proving to be fertile markets. Thus, as production of the basic units increases, the cost will logically be decreased.

Price of the adaptors will not be reduced as much, due to the higher design costs, but will decline somewhat as a library of more standardized and programmable adaptor modules is accumulated. Any integration into the test system of special-purpose computer capabilities or other such sophistications necessarily will add to cost.

• **Future outlook**—The future sales outlook for the automatic test equipment industry is excellent. As we move toward manned space-flight, systems become more and more complex. Advanced communications systems, navigation aids and flight simulators and controllers are coming off the drawing boards at a fantastic rate.

Networks of these systems will not be able to tolerate down-time. Constant monitoring and standby equipment is a basic necessity. Alarm systems to switch in standby gear and trigger off fault isolation subroutines in the permanent monitors will be required to assure rapid replacement of faulty components. Life and failure prediction techniques will have to be built into the periodic maintenance tests to monitor system degradation. All this will require millions of dollars of automatic test equipment.

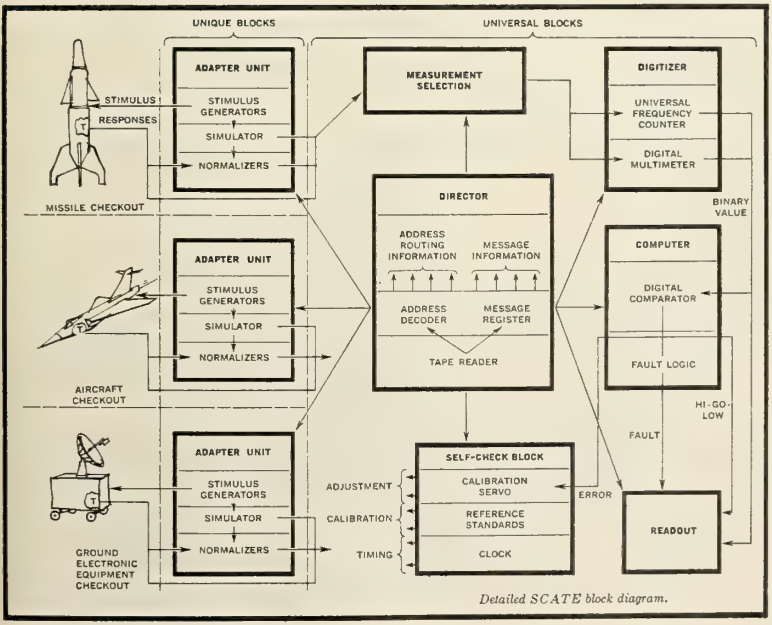
The major challenges facing the industry are basically those of development. A listing of the more important factors poses an ambitious program for producers' consideration:

- The test philosophy must be instilled in systems designers who may then build equipment *capable* of being universally and automatically tested.
- The test philosophy must also be integrated into the Armed Forces logistics system to reduce down-time by assuring supply of replacement components.
- Less expensive basic tester units must be built which are still adaptable to changing requirements and have a potential for growth as systems needs expand.
- The use of fault-isolation techniques should be increased. This reduces the need for trained technicians. However, it should only modify the complexity of the equipment to the point where service technicians may begin manual testing at a function or on a module.
- More universal programmable-type adaptors should be designed.
- Test equipment should be made more flexible and reliable. Sophistication and complexity leads to less flexibility and less reliability.

None of this may be accomplished adequately without primary definition of systems needs by the Armed Forces. Through the cooperation and suggestions of the industry, a well integrated plan of specifications can be written to determine the best possible solution to this problem. Without such coordination, only the chaos of a multitude of specialized equipments can result, causing inefficiency and extraneous expense.

A problem exists and a solution is readily available. Although automatic test equipment is beset by minor difficulties and limitations, these are far outweighed by the advantages of economy of men, money and time which it offers.

The future is bright. Automatic test equipment is the only rational answer to current systems' complexity and future designs hold forth only more complexity. The market for this new universal product is thus assured.



Detailed SCATE block diagram.

responsibility grows . . .

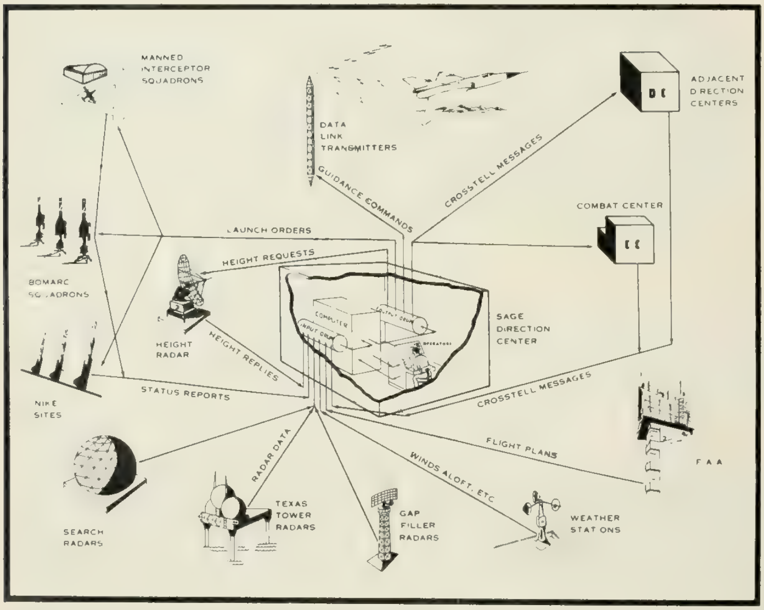
SAGE Guides Interceptor Missiles

Here is an exclusive account of a single computer's role in replacing manual ground control to meet a hypothetical air attack

by Lawrence R. Jeffery

LEXINGTON, MASS.—SAGE's basic mission was to provide a centralized, complete, and timely picture of the air situation over a large area. This mission has grown as the reach of our missiles and manned interceptors has outstripped the range of a manual Ground-Controlled Intercept site using a single radar set.

To improve substantially the GCI radar coverage would require an enormous increase in its transmitted power, and the long-range radar returns would be limited by the earth's curvature to high-altitude aircraft. SAGE (Semi-automatic Ground Environment) sidesteps these limitations by using a digital computer (the AN/FSQ-7) to combine data from widely separated radars and construct a composite situation display, as a large map is produced by piecing aerial photos together.



DIRECTION center communicates automatically with external sites by using digitally-coded data on voice-band-width circuits. The computer is coupled to computers of nearby centers and directly connected to console displays in its own center.

A network of SAGE direction centers (DC's) using these computers is spreading rapidly across the country. Each computer communicates automatically with dozens of external sources such as radars, missile and manned interceptor bases, radio sites, and weather stations. Computers in adjacent DC's communicate directly with each other and with those at higher headquarters.

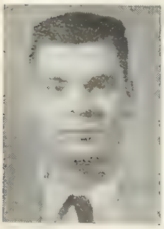
Nearly all SAGE data processing is done by the computer, setting human operators free to make the important decisions and cutting detailed operator coordination to a minimum. To follow the operators' instructions, the computer senses the settings of up to 5000 console switches every 2.5 seconds. To portray the air situation, it generates about 200 different types of displays requiring 20,000 characters, 18,000 points, and 5000 lines.

As the nature of the air threat and our defense weapons provided against it have changed, SAGE has been required to accept greater responsibility. The computer, too, is handling tasks far beyond its original assignment.

- **Alerting the system**—We can see the system components at work by following a hypothetical *Bomarc* interception. Let's begin by supposing that the early-warning network has reported many heavy penetrations by unidentified aircraft and CINCNORAD has alerted all air defense units.

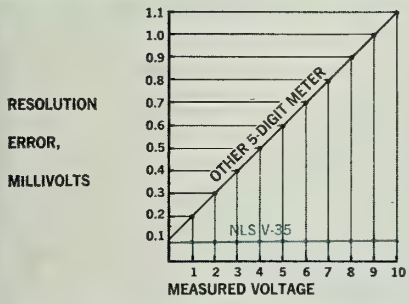
At McGuire Air Force Base, in the big windowless concrete cube housing the SAGE DC for the New York Air Defense Sector, maintenance crews are tuning up the standby computer. They replace any of its 20,000 tubes which do not pass margin tests, for this machine must be ready to take over if the operational AN/FSQ-7 breaks down. The senior director, responsible for the center's operation, has ordered

About the Author



Lawrence R. Jeffery is associate head of the Design Department of the recently-formed MITRE Corporation at Lexington, Mass. He has been engaged in design and development work on the SAGE system since 1954 when he obtained a staff appointment at MIT's Lincoln Laboratory. He earlier worked on computer design at Raytheon and for several years taught mathematics and television engineering in Chicago. He received his M.S. in mathematics from the University of Chicago in 1953.

FIRST DIGITAL VOLTMETER WITH THE FACTUAL FIFTH FIGURE



This chart shows the significant resolution error that results in other five-digit meters as compared to the NLS V-35 with the *factual fifth figure.*

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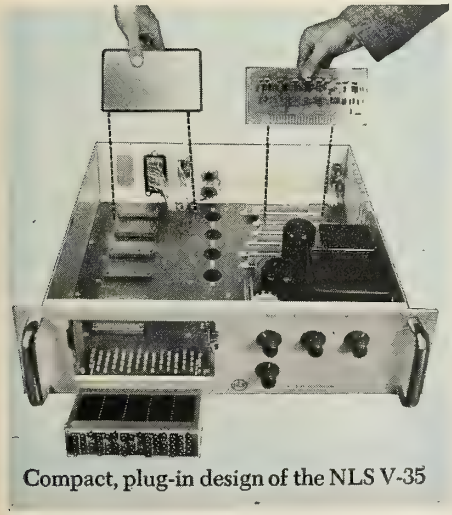

Compact, plug-in design of the NLS V-35

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NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

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operators to their consoles, where the air picture will be displayed and their various actions taken. Following the orders of the sector commander, the senior director has taken the "wartime" switch action on his console, telling the computer that nuclear weapons may be fired. His area of responsibility extends from the Boston Sector on the north to the Ft. Lee Sector on the south and from the Syracuse Sector on the west out to sea as far as his radars can search.

Next to the Syracuse DC is the 26th Air Division Combat Center, having command responsibility over the Boston, New York and Syracuse sectors. The combat center also contains a digital computer (the AN/FSQ-8), which maintains direct, automatic communications with the subordinate direction centers.

• **Tracking the target**—Many hostile aircraft are soon pouring into the East Coast sectors. We will follow one—let's call it Raid Able—as it penetrates the New York Sector and is engaged. Raid Able, we will suppose, has just entered the coverage of the heavy radar on Montauk Point, Long Island, on a course slightly north of west.

The AN/FST-2 data processor at the site converts the radar echoes from Raid Able into a digital message specifying the range, azimuth, and time of the report. Less than a second after the observation, the message is transmitted to the DC. There, the coded return is automatically recorded on a magnetic input drum, which acts as a kind of reservoir for data from all of the Sector's radar sites. The drum stores the data until the computer is ready to use it.

At the proper points in its operating cycle (called a frame), the computer transfers the input data from the drum into its 65,000-register ferrite core memory, clearing the drum so it can be filled with more input data.

The computer then goes about its other jobs. First it converts the new radar data from the ρ, θ form in which it was received into the sector's common x,y coordinate system. Each aircraft track carried by the system is then extrapolated ahead and its position compared with the positions of the new returns. Where a return is sufficiently close to a track, the computer labels it as "correlated" with the track, and will later use it to correct the track's position and velocity.

Since our Raid Able is just entering the system, its returns do not correspond to any of the tracks carried by the computer. Such "uncorrelated" data is saved for use in an automatic track initiation process. The computer also presents these uncorrelated returns on the situation displays (a 19" Charactron cathode ray tube developed by **Stromberg-Carlson**) of the track initiator and track monitor consoles for possible manual action.

Nothing further will happen to Raid Able for about 15 seconds, until the Montauk radar has again swept the eastern sky. In the meantime, the computer:

(1) Updates the positions of all established tracks;

(2) Identifies newly established tracks;

(3) Receives and decodes automatic input messages from *Bomarc*, *Nike*, and manned-interceptors bases, adjacent direction centers, the Syracuse Combat Center, weather stations, and height finders;

(4) Updates its weapon availability tables;

(5) Makes new data entries in its table of winds aloft;

(6) Selects weapons for use against unpaired hostiles and transmits launch orders;

(7) Makes guidance computations for airborne weapons;

(8) Prepares and transmits datalink messages to weapons;

(9) Prepares and transmits weapon and target data of interest to adjacent direction centers and the combat centers;

(10) Transfers air situation and status information to "safe-data storage" in the standby computer;

(11) Prepares air situation and tabular information displays for the more than 100 operator consoles in the surveillance, identification and weapons rooms;

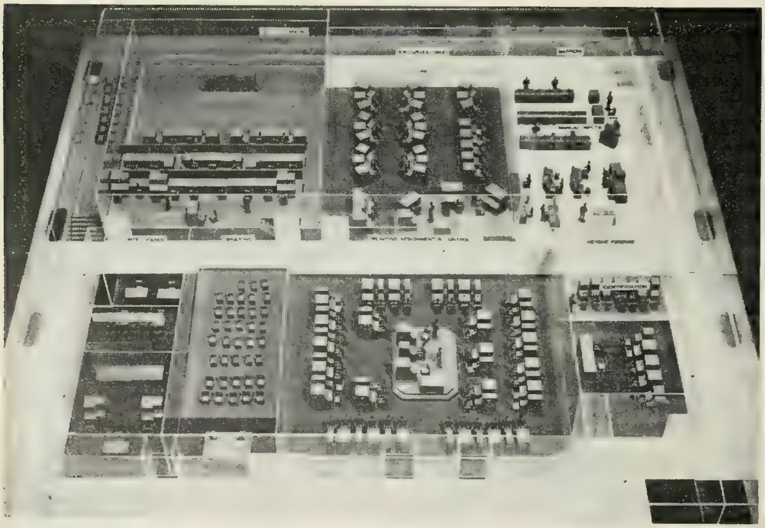
(12) Reads, interprets, and acts upon the console switch actions taken by the operators.

As with any digital computer, the SAGE machine carries out these tasks in accordance with a sequence of instructions (called the program) prepared and stored in the computer's memory perhaps many months earlier. Although each step, or "instruction," accomplishes only one simple arithmetic or logical transaction, very complex processes can be carried out by suitable sequences of those basic operations. The computer's enormous capacity results from its ability to perform more than 100,000 such operations every second.

The next two scans of the Montauk radar bring in still more data on Raid Able—data so spaced in distance and time that the computer, by means of the automatic initiation logic in its program, will recognize these uncorrelated returns as a new track. A position and a velocity are next computed, and Raid Able is entered in the machine's track table as:

Track number	B207
Speed	480 Knots
Course	285°
Altitude	Unknown
Flight-size	Unknown
Identity	Pending

Now that Raid Able is an established track, the tracking program will



FOURTH FLOOR of the direction center contains separate operational rooms for air surveillance, identification, weapons assignment and control, and command functions. Altogether there are more than 100 operational positions.

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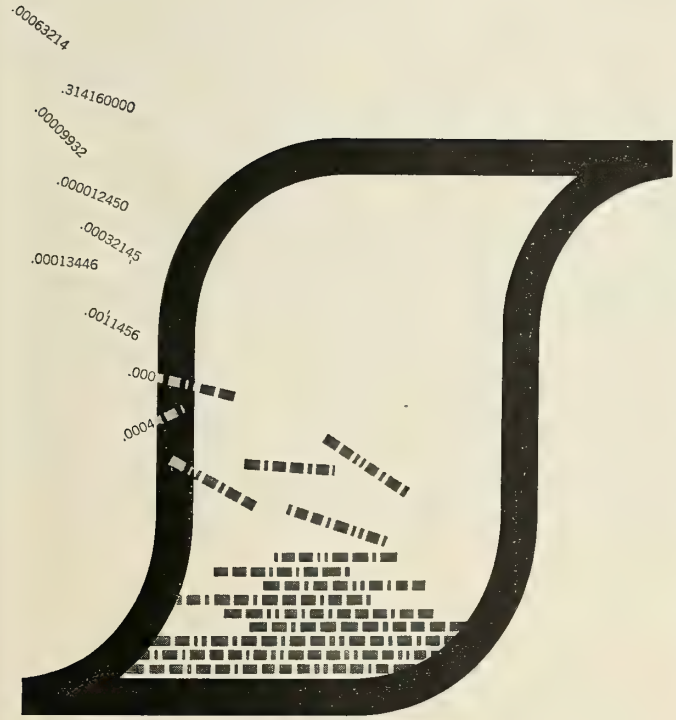

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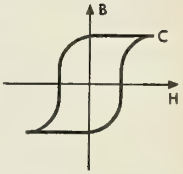

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periodically attempt to correlate with it any new radar data near it. When a return is found sufficiently close to B207's predicted location, it will be used to correct the track's position and velocity.

Since B207 is a new track, the computer places it near the top of the "height priority" table and soon sends a height request message to one of the semi-automatic height finders (AN/FPS-6) at Montauk. The message causes the height finder to slew automatically to the proper azimuth. The operator measures the target's elevation angle and presses a button to send this data back over the phone line to the SAGE computer. The reply reads:

Track	B207
Altitude	43,000
Flight Size	1

• **Identifying the target**—While Raid Able's height and flight size are being determined, the computer adds track B207 to the situation displays in the air surveillance room. In the identification room, the track is displayed with a special attention device, and an audible alarm is sounded in the identification officer's (IDO's) console. The computer also displays to the IDO the positions of nearby commercial flight plans. Since these do not appear to correlate with the track, and since we are already under attack, the IDO presses the follow buttons:

B207
Identify
Hostile
Activate

The activate button tells the computer to read the console's switches. In the computer's memory and on the situation displays throughout the DC, the identity of track B207 is changed to H, for hostile. Now the weapons room enters the air defense picture, and increased activity is focused on track B207.

• **Committing a *Bomarc***—On a dais in the weapons room, next to the senior director, sits the senior weapons director, in charge of all activities in the room. Surrounding the dais are four teams, each headed by a weapons director responsible for committing weapons to targets.

After a weapons director has committed a weapon, the subsequent interception is monitored by one of the five intercept directors on his team. Each officer in the room uses a situation display console, and has an enlisted technician to assist him.

The time soon comes, in the computer's frame, when it must spend a half second or so on the selection of new weapons. It cycles through the list of "hostile" tracks, comparing the number and capabilities of the weapons committed against a track with a standard previously specified by the senior weapons director. When it comes upon any hostile not adequately covered, the computer removes it from the table and acts on it. Track B207 will be one of these.

To select a weapon (or weapons) for use against B207, the program examines each of the sources. The F-106 squadron at Suffolk is the first to be considered. The squadron data table indicates that five aircraft are available on five-minute alert and that the standard armament load for the day is GAR-3 and GAR-4 missiles.

A final-turn tactic is chosen, with combat speed and other tactical parameters appropriate to that armament combination for the speed and altitude of this particular target.

Similarly, the computer picks out an interceptor flight profile (cruise speed and altitude, etc.) to match the geometry of the problem. Next the machine predicts the location of the intercept point and calculates the time-to-go to intercept. This turns out to be twelve mintues.

Finally it determines that this interceptor will require 5400 pounds of fuel to climb to altitude, cruise out, accelerate to combat speed, make the intercept, and return to base. More than this amount of fuel is on board, so the intercept is within range. The Suffolk squadron is therefore listed as a possible weapon source against B207, with a time-to-go of twelve minutes.

Similar computations are performed for the other four interceptor squadrons accessible to the New York SAGE sector and the *Bomarc* squadrons at Otis, Suffolk, and McGuire. The availability status of *Nike* batteries in the Boston and New York AA defense complexes are also checked, and earliest intercept points are predicted. A seven-minute time-to-go is shown by the Suffolk *Bomarcs*, and this is substantially shorter than can be obtained against this target with any of the other weapon sources. The computer therefore selects (still tentatively) the Suffolk *Bomarcs* for use against track B207. This entire selection process, including all of the computations for all the weapon sources, occupies the machine for less than one-twentieth of a second.

Based upon the location of track B207, the computer selects weapons director No. 2 to be responsible for it, and notifies him with an attention display. The display also indicates the computer's recommended course of action (i.e., fire a *Bomarc* from Suffolk) and the predicted intercept point corresponding to that choice.

The WD indicates his concurrence by pressing a button on his console (if he did not agree, he could choose an alternate weapon source). Within a few seconds, the computer transmits a "fire" message to launcher No. 31 at the Suffolk *Bomarc* squadron. Seconds later, the booster ignites and the missile rises from the launcher. When it reaches altitude the *Bomarc* levels off and cruises under the power of its ramjets.

An automatic message flashes from the launcher to tell the SAGE computer the *Bomarc* is airborne. The computer assigns track number AB15 to the missile. By this time it also has selected one of the WD's five intercept directors to assume responsibility for the mission.

The selected intercept director's situation display shows the locations of Hostile B207 and Missile AB15 and the predicted intercept point. Both the missile and the target are now being tracked and a series of guidance computations will steer the missile and periodically up-date the predicted intercept point.

• **Guiding the missile**—The guidance computations take into account the target's position, speed, heading and altitude, the missile's position, altitude and speed, and the velocity of the wind (weather data in its memory). From these inputs it computes:

(1) Missile mid-course heading
(2) Missile attack heading
(3) Time-to-go
(4) Seeker azimuth orientation
(5) Seeker elevation orientation
(6) Location of intercept point.

When the computer notices that target speed, heading, or altitude has changed significantly, the computations are repeated. It takes about one-fiftieth of a second to perform them once.

The computer then codes necessary command information into the proper format for transmission. It also must consider the location of the missile in relation to all of the data link transmitter sites in the sector and select the site from which the missile will receive the strongest signal. A digital address for the selected site and the address of the missile (AB15) are added to the message, which is then recorded on the computer's output drum.

Like the magnetic input drum, the output drum acts as a kind of reservoir, but in reverse. The computer fills it up quickly with outgoing messages such as the data-link commands for all weap-

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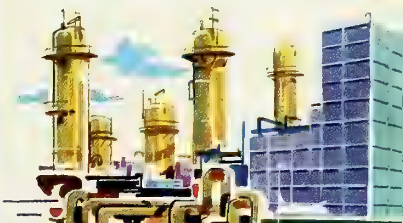

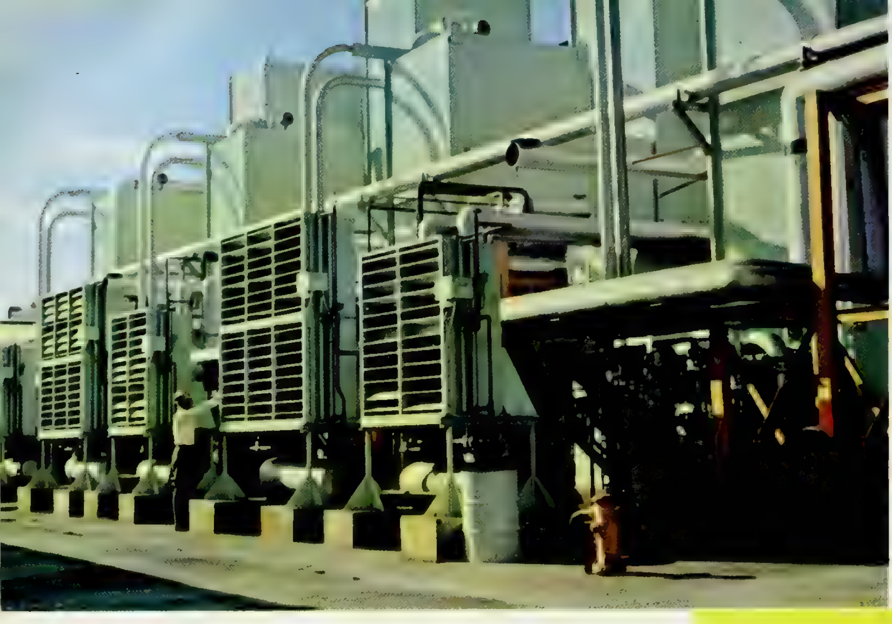

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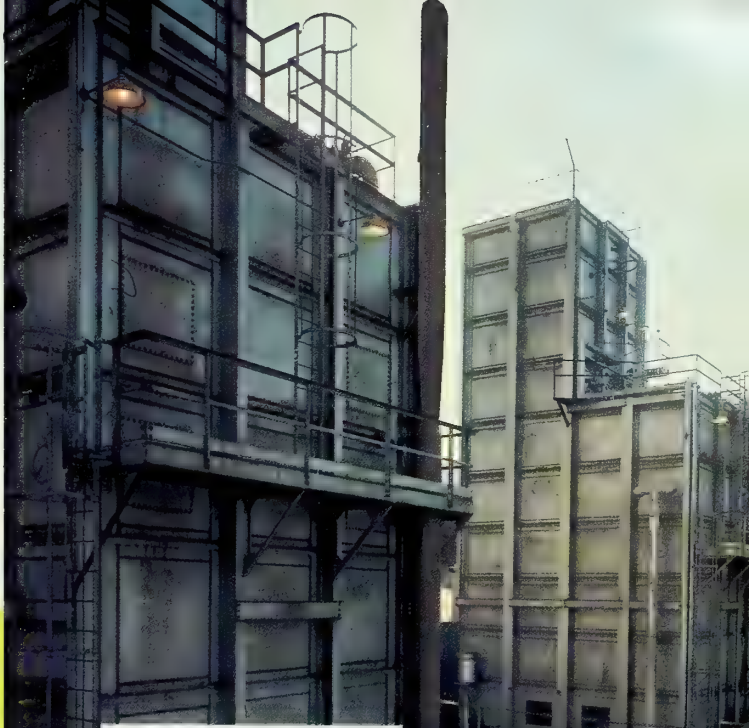

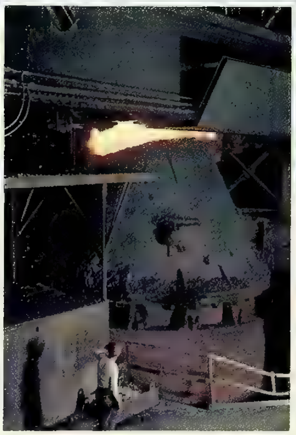

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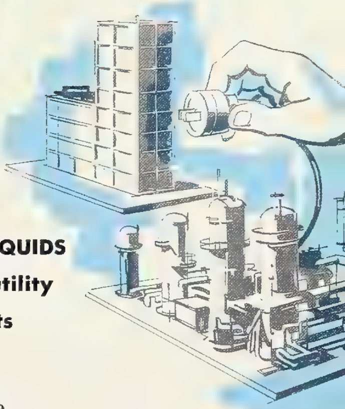

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ons. Then, while the computer is doing other jobs, the drum "slowly" doles out its data to the phone lines. It will be empty by the time the computer has more information to record on it.

When the message for AB15 is placed on the phone line to the data-link network, the appropriate data-link site recognized the address, accepts, and radiates the message in a fraction of a second. AB15 receives the message and makes the necessary adjustments in its course.

- **Handover**—When time-to-go is down to about four minutes, the course of track B207 shifts still more to the north, and the predicted intercept point drifts across the sector boundary. Raid Able is apparently headed for Boston, and his present course will soon carry him into the Boston Sector.

Accordingly, the New York computer places a special symbol about this track's display, alerting operating personnel that it is about to be transferred, and sends a "crosstell" message to the Boston computer, giving data about the track and the missile paired with it.

Boston almost immediately begins tracking the target with data from its own radars and notifies New York that the transfer has been made. Missile AB15 is still in the New York Sector, where it is being tracked and guided.

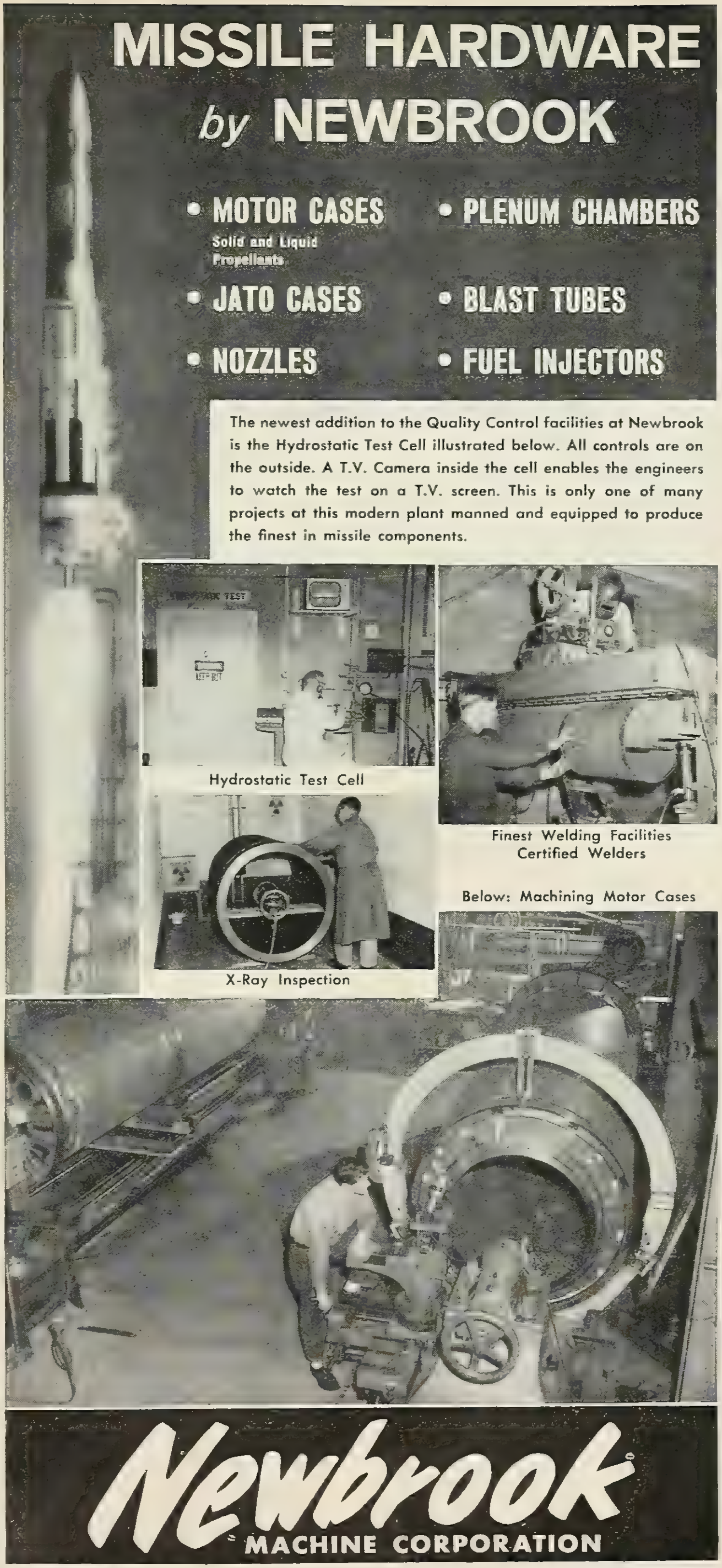
As Missile AB15 nears the border, the controlling intercept director is alerted and the New York computer dispatches a crosstell message containing the missile's position, speed, heading, altitude, fuel remaining, and tactical parameters. Boston's computer selects an intercept director to monitor the rest of the mission.

New York drops out of the picture by transmitting a final data-link message to *Bomarc* AB15, commanding it to re-tune its data-link receiver to the frequency of the Boston network.

Boston now has complete responsibility for guiding the missile to its interception point. It tracks, computes the intercept, and transmits guidance commands. When the missile's seeker is activated, the missile turns to its attack heading. AB15 is now a few miles from the hostile, a few thousand feet above it, and on a collision course.

The radar seeker is aimed directly at the target and scanning. When the seeker locks on, the missile dives, and its proximity fuse detonates the warhead at its closest approach to target.

The stoppage of radar and beacon returns from the target and missile tells the Boston computer that the mission is accomplished. On the machine's recommendation, an operator in the Air Surveillance Room takes a switch action to erase AB15 and B207 from the computer's active memory.



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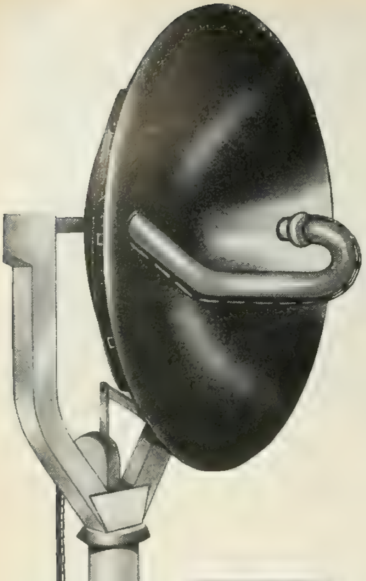

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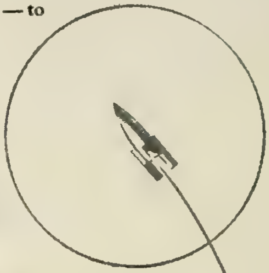

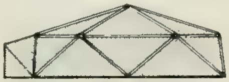

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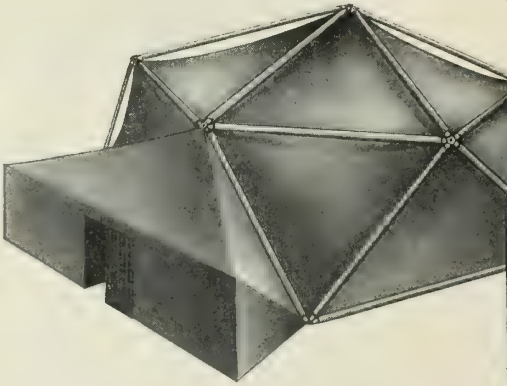

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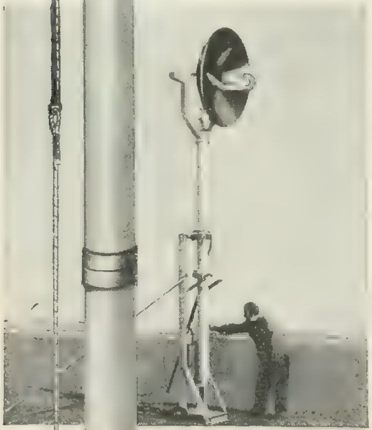

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BMEWS—A Billion-Dollar Investment To Fulfill One Objective

America's electronics giants unite to give us 15-minute advance warning of ICBM attack

by Charles D. LaFond

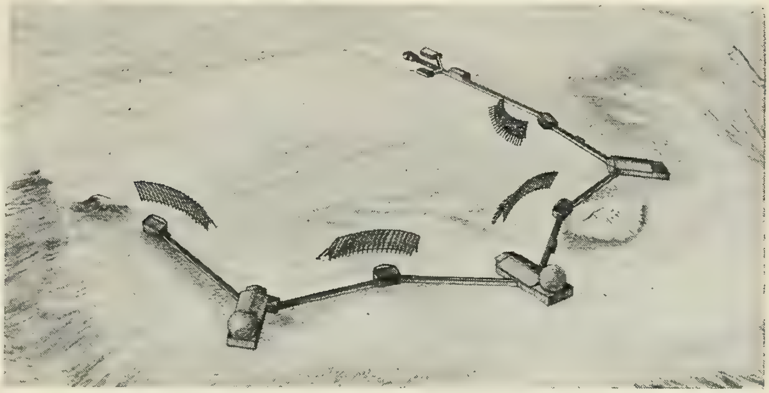

FIG. 1—Artist's conception of a typical BMEWS site layout. The huge plastic sphere surrounding the tracking radar when mounted on the radar building will tower to the height of a 15-story office building.

MOORESTOWN, N.J.—The Ballistic Missile Early Warning System (BMEWS) is a billion-dollar product of an evolution of national defense weapon systems. The concept is an accumulation of new ideas fostered by a need for protection against modern weapons —weapons which have surpassed available defensive hardware and destroyed our former complacency. An unusual part of the evolution is its very brief time span.

Early in 1958 the Air Force announced that the **Radio Corporation of America** has been designated as prime contractor for the design and construction of the BMEW system. Because of the rapid development of ICBM's, it had become necessary to construct a high-powered, long-range radar system having a series of forward sites at northern locations to detect any enemy missiles that might be launched toward the United States or Canada.

A polar projection immediately reveals why the forward sites had to be located in northern regions; the shortest missile trajectories from the USSR to the United States are across the polar area. Typical approximate distances to principal U.S. cities include 3000 miles to Los Angeles from Siberia, 4000 miles to Chicago from Siberia, and 4500 miles to New York City from northwest Russia. All of these distances are well within the range limits of present ICBM's.

Early plans for the system called for three high-powered radar stations in northern latitudes plus a central computer and display facility in the continental United States. The latter was located at the North American Air-Defense Command at Colorado Springs.

Two sites have been definitely established; Clear, Alaska, and Thule, Greenland. The third site reportedly will be established somewhere in Scotland (this final selection is currently under negotiation with the British, following the survey of eleven potential sites).

BMEWS has one primary objective: to provide at least a 15-minute warning following the detection of a mass ICBM attack. This warning will alert military forces and furnish information to civil defense agencies. Thus it complements the DEW Line, which is designed to detect aircraft and air breathing missiles.

Tentatively, an $822.7-million ceiling has been set by the Secretary of Defense for BMEWS implementation. This includes Sites 1 and 2 and the U.S. control facility. An additional $98 million (estimated) will be needed to

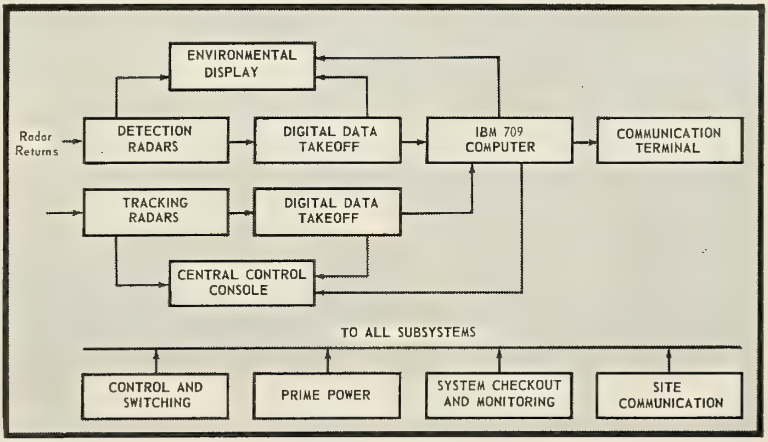

FIG. 2—Major elements of the BMEWS system.

complete Site 3. Because of the joint utilization of this site (Scotland), the British will probably contribute an estimated $21.7 million of the total required.

An estimated $91 million of the total above will be utilized for rearward communication facilities from Sites 1 and 2.

The original letter contract award to RCA was for $200.1 million. **Western Electric Company,** under separate Air Force contract, received $30.8 million as prime contractor for rearward communications. It has been estimated that up to the initial operating date of the system, RCA will have been awarded a total of $440 million and WECO a total of $85.7 million.

In developing BMEWS, RCA is supported by several major subcontractors, including the **General Electric Company, Sylvania Electric Products,** and the **Goodyear Aircraft Corporation.** Construction will be accomplished by U.S. Army Corps of Engineers.

Such a combination of talents and facilities indicates the complexity of the system as well as the typical teamwork that exists within American industry on defense contracts.

The BMEWS system will be linked with the Command Headquarters at Colorado Springs through a communications network being constructed under a separate contract by WECO.

- **Evolution of complex systems**—H. W. Phillips, RCA manager of BMEWS Operations Administration, has stated that approximately 80% of the products and services furnished to present-day weapon systems by the electronics industry were not available as recently as 10 years ago. This is not surprising, he said, when we consider the evolution of the weapon system concept itself and the rapid development of new electronic and mechanical components.

Only since the early days of World War II have we seen the results of advanced development and application of such techniques and equipments as jet propulsion, nuclear and thermonuclear weapons, atomic power, missiles, satellites and similar advanced systems.

During World War I, weapon systems, as we now interpret the term, were unknown. Officers evaluated battle situations and issued orders to men who took action with manual weapons—rifles, bayonets, machine guns, and artillery. As a result, military operations were slow and inefficient by our present standards.

Shortly before and during World War II, techniques and equipment were refined so that effective electronic weapon systems became a reality. The first system of this kind involved anti-aircraft weapons. These were controlled manually or semi-automatically, based on information obtained from sound and optical trackers, search-lights, computers and gun directors. Unfavorable weather seriously hampered operations, however, and searchlights revealed the position of anti-aircraft units.

The development of radar radically changed the system. Detection became possible under all weather conditions and at ranges of several hundred miles. The next step electronically united the radars, computers, and guns for accurate fire control. This, then, was a simple integrated weapon system.

Many other achievements occurred during World War II that led to complex weapon systems: advanced jet aircraft engines were developed; guided missile work began; advanced fire control systems were developed for ground, shipboard, and airborne applications; and nuclear energy was harnessed as a weapon and as a source of power.

Since the end of World War II, some of the greatest advances in the defense program have been accomplished in the electronics field. Radars, computers, and communication equipment have been greatly refined. Transistors, printed circuitry, and micro-miniature modules have contributed tremendously to our superior electronic equipment. Undoubtedly, said Phillips, the development and application of miniaturized electronic components is helping us to maintain our position as a world leader in perfecting complex weapon systems.

- **Design configuration**—In the final configuration, it is contemplated that BMEWS will feature RCA-designed tracking radars and General Electric detection radars. The detection radars are being developed in conjunction with the Lincoln Laboratory of Massachusetts Institute of Technology and ARDC.

Together, these radars will detect and track an invading missile as it appears above the horizon. With the aid of a high-speed electronic computer and associated equipment being provided under subcontract by Sylvania Electric Products, altitude, speed, and trajectory of the target will be established.

The Goodyear Aircraft Corporation, as one of the three major subcontractors, is responsible for the design and production of the tracking radar antenna pedestal assemblies and the 140′ diameter rigid spherical radomes to protect radars.

Fig. 1 shows a possible layout of a BMEWS site. The sizes involved are impressive. The huge plastic sphere surrounding the tracking radar antenna when mounted on the radar building will tower to the height of a 15-story

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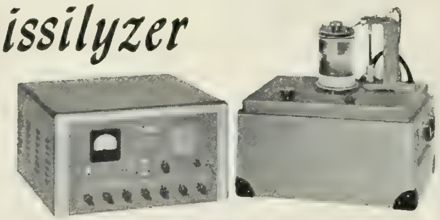

The new Kay Missilyzer is an audio and sub-audio spectrograph designed for missile data reduction and analysis of missile and rocket engine noise. It can also be used for ships, aircraft and for rotating and reciprocating machinery in ordnance, ballistics, seismology. acoustics, biophysics.

The Missilyzer produces permanent visual records of complex wave forms to 15 kc and provides three different analyses of these wave forms. The first analysis relates frequency and intensity to time. The second, relates intensity (over a wider dynamic range than the first) to frequency at a particular instant of time. The third display shows the available average amplitude versus time.

The unit is equally suitable for steady state measurements.

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FREQUENCY RANGE: Standard models, 5-15,000 cps, in bands listed below.

	Analyzing Filter Band		Duration Recorded Sample
Freq. Range	Narrow	Wide	
5-500 cps	2 cps	20 cps	24 seconds
15-1500 cps	6 cps	60 cps	8.0 "
50-5000 cps	20 cps	200 cps	2.4 "
150-15,000 cps	60 cps	600 cps	0.8 "

RECORDING MEDIUM: Magnetic Drum.
FREQUENCY CALIBRATION: Calibration markers at 30 cps or 240 cps intervals may be recorded on analysis paper.
RECORD-REPRODUCE AMPLIFIER CHARACTERISTICS: Frequency response switchable to provide flat or (for transducer usage) either 44-db or 60-db falling characteristic.
TWO IDENTICAL RECORD CHANNELS: May be employed independently or in parallel.
PICKUP DEVICES: Vibration pickups, microphones or other properly matched devices can be used.
INPUT IMPEDANCES, SWITCHABLE: High, 1.8 Megohms for low level and microphone input. Low, for high level signals, such as from tape recorders.
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PORT OF EMBARKATION

In the decade of missilery ahead, prime contractor capability must go far beyond the requirements of hardware design and manufacture. New experience and facilities are now required in the increasingly critical launching phase—from ground handling and testing to countdown and data control.

Martin's Cocoa Division is the first organization of its kind devoted exclusively to this specialized area. Accomplishments have already established new operational standards at Cape Canaveral, one of the two U.S. ports of embarkation for the major space events of the decade ahead.

An example of the latest development in electronic fail-safe launching equipment is the new Martin Master Operations Control [MOC] system, which automatically monitors count-down procedures in the test firing of research and development-type TITAN missiles. With equipment such as this, TITAN launchings have achieved unheard-of performance reliability.

The Cocoa Division
is one of the
seven divisions
of The Martin Company

MARTIN
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office building. The detection radar antennas each have more area than a full sized football field. These are stationary—scanning action is accomplished by moving a beam mechanically or electromechanically.

Technically, it is significant that the system required increasing the range capability over the present radars, such as those used on the DEW Line, by a factor of 10 to 1. This could be done theoretically by increasing power by a factor of 10,000, but this is well beyond the feasible economic limits. The second approach was the construction of much larger radar antennas to obtain increased range by concentrating the energy in a narrower and a more efficient beam.

In addition to the necessity for providing longer range so that early detection is possible, it is also necessary to provide frequent coverage of the area being observed so that targets cannot slip through without detection. This is accomplished by developing the best compromise between pulse rate and pulse length.

• **Reliability**—According to R. H. Baker, program reliability manager at RCA, one of the overriding considerations in connection with the design, development and production of BMEWS is the high reliability requirement. In order to afford full protection, it is essential that the system be capable of staying on the air continuously.

The required reliability, said Baker, is being achieved through careful application of thoroughly developed reliability techniques in connection with the development of the system concept, the physical design of the hardware, and the production and installation of the equipment.

• **Operation**—Fig. 2 is a functional chart showing the major elements of the system and their relationship to each other.

The "Data Take Off" provides a fundamental part of the system capability by furnishing preliminary detection information and transforming analog radar returns to digital form. The tracking and detection radars require separate data-take-off equipments because of the differences in the generated signals.

The site computers are known as "track initiation and prediction" computers. Two IBM solid-state digital computers make up this duplex, which is operated on a real time basis (computer operations are concurrent with the events on which information is being generated).

Target trajectories are computed from the digitized target information and the computed trajectories are compared with known courses and charac-

(continued on page 78)

Atlas Beams U.S. Peace Plea

WASHINGTON, Dec. 19 — The voice of President Eisenhower, broadcasting from the Atlas satellite in space, today was heard in a dramatic Christmas message calling for peace on earth.

As the San Diego-built rocket raced overhead at 17,000 miles an hour the communications system flashed these words:

"This is the President of the United States speaking. Through the marvels of scientific advance, my voice is coming to you from a satellite circling in outer space.

"My message is a simple one. Through this unique means I convey to you and to all mankind America's wish for peace on earth and good will toward men everywhere."

Mr. Eisenho lans to
transmit
the Yule
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field test engineers

If you are a versatile, practical minded engineer with a true flair for excitement, Convair Astronautics would like to discuss with you the opportunities now available at its test bases. There is no sight quite like the mighty ATLAS as it rises majestically into the sky. The dramatic future of test base work will include "space shots" to the moon, orbiting of other planets, as well as the much talked about Mercury "man in space" program.

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Most important requirement for these positions is versatility — that blending of education and experience which equips engineers to think in terms of hardware under field conditions. Openings exist at Cape Canaveral, Fla.; Vandenberg AFB, Santa Maria, Calif.; Edwards Rocket Base, Boron, Calif. and Sycamore Canyon, San Diego, Calif.

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mostly for building and support . . .

PMR Plans to Spend $256 Million

The nation's largest missile and space vehicle range includes only base from which polar launches can be made, will be heavily used by services and NASA.

M/R Staff Report

POINT MUGU, CALIF.—Over a quarter of a billion dollars is planned to be spent during the next few years to develop the nation's largest missile and space vehicle range.

And most of this money will be spent for construction and missile support equipment.

The Pacific Missile Range—run by the Navy with the **Bendix Corp.** and the **Texas Transportation Corp.** as prime range contractors—is already the largest range in size (65,000 acres of water and land). Present and future expenditures will give it the most extensive facilities.

PMR is really four ranges:

- The Inland Range—which stretches eastward from Tonopah, Nev. to Dugway Utah, tests short range surface-to-surface missiles;
- The Sea Test Range—extends 500 miles south paralleling the California coast and is used for testing short-range air-to-air and air-to-surface guided missiles and medium-range surface-to-surface missiles;
- The IRBM-ICBM Range—centered at Vandenberg AFB extends thousands of miles over the Pacific, allows long range tests with maximum telemetry and safety;
- The Space Range—at Point Arguello, is the nation's only range having the unique geographical advantage allowing polar orbiting satellites to be fired with complete safety.

PMR presently employs 6500 and has a yearly payroll of $35 million. By the end of FY 1960, over $151 million will have been spent on the base. During the next few years, a total of $256 million will have been spent. The final figure may be in the billions.

Like its sister bases—the Atlantic Missile Range run by the Air Force and White Sands run by the Army—PMR is used by all four services and both space agencies. Base Commander Rear Admiral Monroe has as his Deputy Commanders representatives of the Army, Navy, and Air Force, and soon will have a Director from the National Aeronautics and Space Administration.

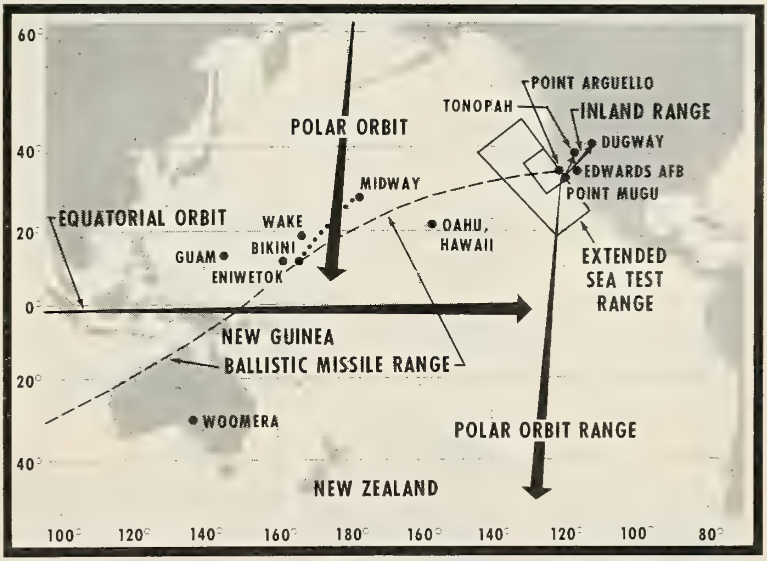
What does PMR intend to spend its quarter of a billion dollars on? The primary market will be for construction. Buildings, fuel storage, high explosive magazines, facilities, frequency control facilities, warehouses, and additions to many existing but inadequate facilities.

Missile support equipment needs range from mobile instrumentation stations, vehicles, and towers, to the various small electronic components that form the guts of any missile test center.

PMR does not duplicate the work of AMR or White Sands. AMR was constructed as a research and development center for long range guided missiles, and White Sands performs the same function for shorter range air-to-air, surface-to-surface and surface-to-air guided missiles.

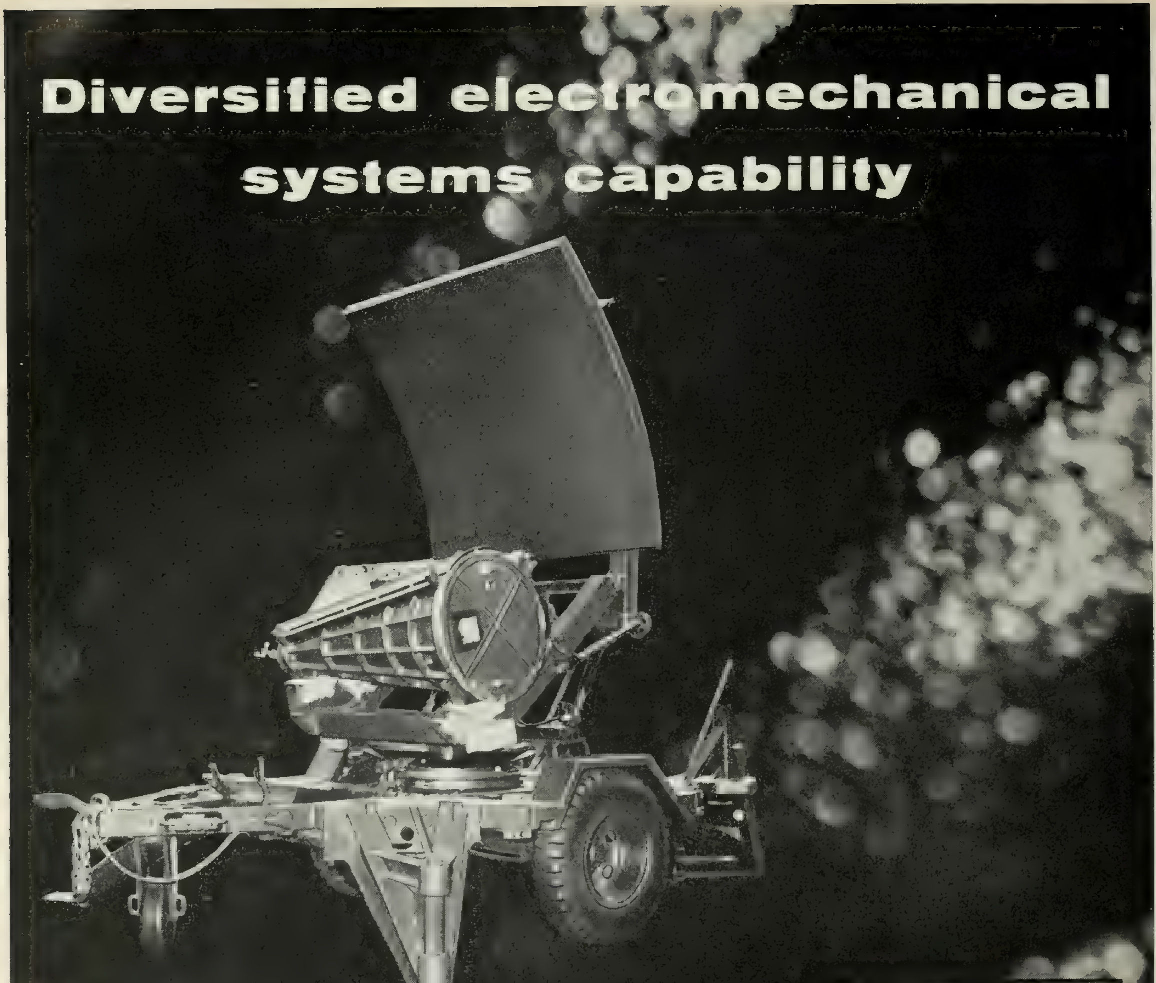
Except for *Polaris* and other Navy missiles, PMR is used for training crews to fire the missiles once they become operational.

The Point Arguello space range, as was explained before, carries out a function that no other launch base can. It is the only base that can put a satellite safely into a polar orbit—there is nothing between Point Arguello and the South Pole except water. This provides an excellent fall-out area for the booster and also a large safety area for destruction of vehicles which do not go into proper orbit.



ACTUALLY four ranges in one, the vast Pacific Missile Range already includes Inland Range in Western U.S., Sea Test Range south from California, IRBM-ICBM Range from Vandenberg AFB west, and Space Range at Point Arguello.

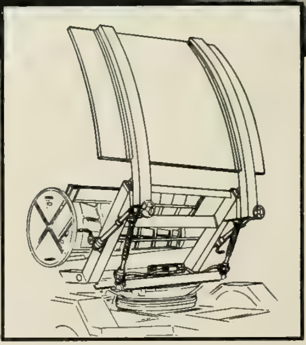
Diversified electromechanical systems capability



AiResearch Actuation Systems For Portable Radar represent a typical electromechanical systems application in ground support equipment. Two types of AiResearch actuation systems are now in production for the Army's mobile trailer-mounted ground radar unit. They consist of a manually operated antenna folding storage system and an electrically powered antenna elevation system.

Designed to operate under the most severe environmental conditions, this type of electromechanical system can operate on 60 cycle A.C., 400 cycle A.C., or 28 volt D.C. Other suggested applications include: *missile launchers, missile ground handling and support equipment, armored vehicle fire control and ballistic handling systems, and mobile communications equipment requiring servoed actuating systems.*

AiResearch leadership in the development and production of electromechanical equipment for aircraft, ground handling, ordnance and missile systems of all types also includes such recent examples as spoiler servo control systems, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting. We invite you to submit a problem statement of your electromechanical requirements.



U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.

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Because of its peculiar needs, the Army's *Nike-Zeus* anti-missile missile will be tested at PMR.

PMR grew from the early Navy missile base at Point Mugu which was set up in 1946 to test short range missiles for use with the fleet. Early missiles developed at Mugu were the *Loon* (modified German *VO1*) and the surface-to-surface *Lark*. These missiles were the forerunners of the Navy's air-to-surface *Bullpup*, air-to-air *Sparrow's I* and *III*, and the surface-to-surface *Regulus I*.

The reason that Point Mugu and the surrounding area stretching 90 miles north to Point Arguello was picked to become the largest missile and space vehicle range were: (1) it offered more launching room for long range missiles and could launch satellites into polar orbits; (2) launches could be conducted in complete secrecy; and (3) there were no inhabited areas within 10 miles of the facility, offering greater safety to the civilian populace.

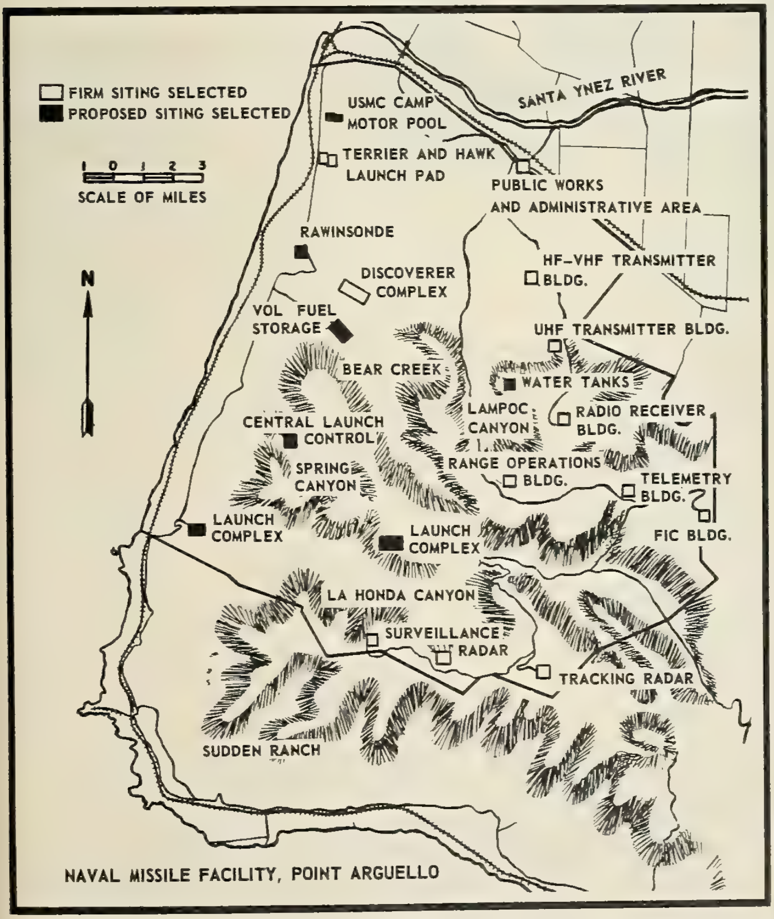
Point Arguello, originally the Army's Ft. Cooke, was brought into the PMR complex in 1958.

The three biggest installations already constructed or under construction at PMR are the *Thor*, *Atlas* and *Titan* complexes. Eight *Thor* pads are nearing completion and three *Atlas* pads are ready to handle the nation's first operational ICBM.

Joining these complexes in the future will be installations for the *Minuteman*, the *Nike-Zeus*, and for the larger NASA space vehicles, such as *Centaur*, *Vega*, *Saturn*, and *Nova*, now under development.

NASA, which has not used PMR in the past, intends to make extensive use of it in the future. Joining ARPA satellites launched from PMR will be NASA polar orbiting satellites and communications satellite.

An integral part of the space operation, when built, will be the equatorial launch site tentatively slated for construction on Manus Island in the Admiralty Islands Group.



POINT ARGUELLO boasts the nation's only missile range permitting completely safe launching of satellites into polar orbit. South of the point is nothing but open water, providing fall-out area for booster and room to destruct erratic birds.

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PAN AM

Guided Missiles Range Division
Patrick Air Force Base, Florida

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ICBM Facilities

(continued from page 47)

fuel system and all the cryogenic systems are located here.

The missile is stored in a horizontal position, attached to a motor-driven erection boom with which it can be raised to a vertical position. When the missile is vertical, boom clamps are withdrawn and the boom is moved away from the missile so as not to interfere with launching.

The vertical missile sits directly over a concrete flame pit which curves away to deflect flame and hot gases from its vicinity. The terrific heat energy released into this pit when the engines fire is almost beyond imagination; alloy steel melts like butter unless cooled by large volumes of water. Hence, steel flame deflectors are not economical for operational sites and concrete deflectors have been designed to ablate without harmful deterioration.

In normal readiness, the missile will be stored horizontally with roof and flame pit exit doors closed against blast effects of a possible enemy missile. All liquid fill lines are capped, and air intake and discharge openings have blastproof covers which will automatically close whenever an external blast occurs and will remain closed until the danger has passed.

• **"Buttoning up"**—Connected to the Launch and Service Building by a tunnel is the Launch Operations Building, containing the Control Room and communications equipment and the electric power generating equipment, as well as sleeping quarters for the operating crew and air conditioning, electric power generation, cooking, and domestic water facilities. Everything is on an austere basis but complete in every detail; the operational crew can "button up" in complete isolation from the outside world except by telephone.

During an alert, or during exercise of the missile, all crew members are withdrawn into the Operations Building for protection against operational hazards. From here, they can carry out a complete countdown and launching by remote control.

Each complex is self-sufficient during the "button-up" period, retaining its capability to strike back even though all power lines are knocked out in the area, all water supplies cut off, all roads blocked or destroyed, and all local communications inoperative. And each individual complex is located far enough away from every other complex so that any conceivable multi-megaton thermonuclear bomb which might knock out one missile would be too far away to adversely affect others.

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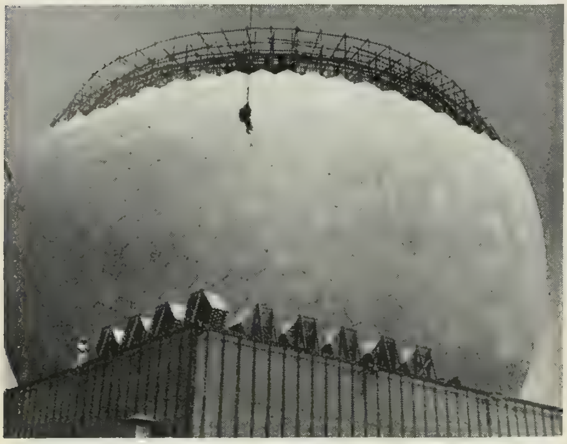

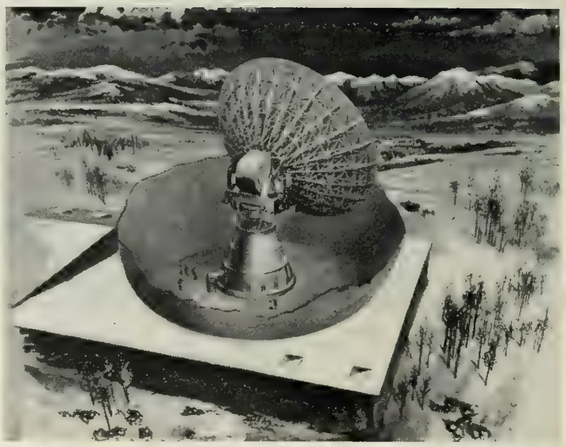

FIG. 3 (at left)—Recently completed near New Jersey Turnpike just east of the Camden-Philadelphia area, is a prototype of similar installations to be constructed in the Far North. The dome will provide protection for huge antennas inside. It was fabricated by Goodyear Aircraft. FIG. 4 (at right)—Artist's cutaway drawing shows in-location installation at a Far Northern site of BMEWS tracking antenna and supporting pedestal being fabricated by Goodyear under a multimillion-dollar RCA contract.

teristics of satellites, aurora, meteor trails, etc. The computers then make strategic decisions in designating tracking radars to cover specific targets on which more information is required.

Finally, they are capable of formulating messages for transmission to the display in the Zone-of-the-Interior. The information from the detection and the tracking radars is fed into the two computers simultaneously.

One computer performs the more detailed computation and acts as the active computer. As answers are generated they are transmitted on through the system for evaluation and in parallel are fed into the second, or standby, computer for a correlation check.

The second computer is operated on a simplified program so that it will have an answer ready for comparison with the answer generated by the active computer.

Correlation, of course, is a relative matter and is based on whether or not the answers agree within specified limits. If a variation is noted that is beyond the specified tolerance, the built-in checking capability of the computers is put into operation and also the system checkout equipment checks each computer automatically to determine which one is in error. Proper corrective action can then be taken.

BMEWS is provided with a comprehensive and completely automatic checkout and monitoring system. This system according to RCA is believed to be the most extensive automatic checkout and monitoring system that has been built up to this time. The principles being used have all been proved in a similar system built by RCA for the *Talos* Ground Launch System. This system has been in operation successfully for about 1½ years.

One major advantage of the checkout system is that it makes possible the isolation of a malfunction without the necessity of system shutdown.

Signals from the checkout and monitoring system are fed into BMEWS and then at specified monitoring points the outputs are compared against reference outputs generated by the checkout and monitoring system. Variations that are out of specified tolerances indicate problem areas requiring further check.

At the Zone-of-the-Interior facility, the data from the forward sites will be decoded, evaluated, modified by other intelligence and displayed. This action provides the basis for evaluation of the potential threat and the determination of whether a decision for action is required.

- **Engineering problems**—It is impractical to provide a detailed description of all of the major elements of the BMEWS system, but a few of the specific engineering problems that have been encountered can be discussed.

The first problem encountered was with the radome. It had to be capable of withstanding winds as high as 185 miles per hour and temperatures as low as minus 65°F. Since it is installed on top of a building, the coefficient of drag is higher than would be the case for a radome installed on the ground. The drag coefficient for a radome installed in the usual fashion is about 0.38. The coefficient of drag for the BMEWS radome is 0.657 or almost 1¾ times as great.

Wind tunnel tests made on the model of the radome developed that the total lift could be almost 1.4 million pounds, total drag could be nearly 1.14 million pounds and the overturning moment could be over 58 million foot-lbs.

The radome is of sandwich construction with skins made of reinforced plastic impregnated fiberglass with a phenolic impregnated paper core. The

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panels are hexagonal in shape, 6″ thick, and about 6′ across. It takes 1,646 of them to make one radome. The panels will be bolted directly together without any additional framework or structual support.

Fig. 3 shows how the panels are fastened into final radome form. The elimination of structual support reduces the transmission losses by a factor of approximately 10. This is a highly desirable end result. More important still, the bore sight error will be less than 0.3 mils. However, the elimination of the frame introduces certain mechanical design problems. The principal one is to reach the best compromise between tension and shear loading of the bolts. The influence of the heavy wind loadings is not only a major factor in this connection but also in connection with the design of the non-rigid base ring made as a part of the building structure to support the radome.

The low-temperature environment was also a serious problem to reckon with in connection with the design of the detection radar reflector. Welded structures made of conventional structural steel are subject to failure at low temperatures. A transition of the physical properties of the metal occurs and causes a serious reduction in strength. To assure adequate strength to withstand the heavy wind loadings under the extreme low temperature conditions it was necessary to utilize a nickel steel with suitable low temperature properties.

Fig. 4 shows an artist's conception of the tracking radar reflector radome, and building. The total weight of the rotating mass is over 200,000 pounds. When it reverses direction, the deacceleration and acceleration take place at about 25°/sec., which imposes a loading of nearly 1 g.

Considering that the center of gravity of this rotating mass is about 85′ above ground it is obvious that mechanical problems would be involved in designing the pedestal assembly, drive mechanisms, gears, bearings, support and the pedestal base itself. The main bearing in the pedestal which carries the load is designed to be capable of continuous operation for at least a ten-year period.

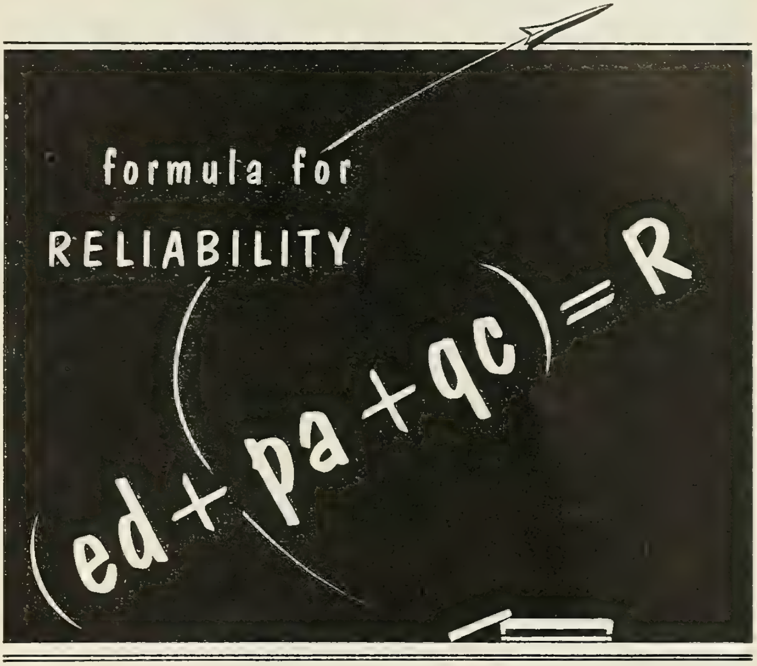
One of the phenomena that causes difficulty in far-north construction is permafrost (frozen earth below a certain ground level that maintains its frozen state). Since there is a thaw during the summer season, it is necessary to use non-frost-susceptible material (referred to as NFS) where buildings are to be constructed. It is necessary to use the NFS so that the heat from the buildings will not melt the permafrost and thereby cause the buildings to settle.

Large plastic tents are used during the cold weather to permit construction work to continue. The tents are kept inflated by pumping in heated air, which also makes it possible for the work to be performed under reasonably tolerable conditions.

- **Test installation**—An engineering-test and personnel-training installation is being constructed at Moorestown, New Jersey (Fig. 3). It will house a complete tracking radar and will have installed for protection of the radar one of the 140′ diameter radomes.

Included as part of the test installation will be other parts of the complete system that are associated with the operation of the tracking radar. This will include the high power transmitting apparatus for probing the distant sky, and the high speed computers for calculating speed and direction of an approaching ballistic missile.

Two types of radar transmitters currently are under development: a triode and a klystron amplifier. Following extensive tests, one will be selected for multiple procurement and use at the sites.



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Division of General Motors, Indianapolis 6, Indiana

Army Establishing Missile Support Base in France

by Anthony Vandyk

CHATEAUROUX, FRANCE—The U.S. Army plans to establish a European Inventory Control Point here for supply and maintenance support of certain guided missile systems furnished to NATO nations.

The Inventory Control Point will be incorporated in the NATO Maintenance Supply Service Center which has been established at Chateauroux. This center is currently managed by the U.S. Air Force but it probably will be turned over to NATO in the middle of 1961.

At the moment all missiles and their support equipment supplied from the U.S. are shipped by ocean surface transportation except for certain high-priority items as some special equipment. In these cases air transportation is used. USAF officials believe the outlook is good for increased emphasis on supply by air.

Today there are relatively few U.S. missile units in Europe. The U.S. Air Force has only three missile bases—all located in West Germany. The missile units are under control of the 38th Tactical Missile Wing, headquartered at Sembach Air Base Germany, and include the 587th Tactical Missile Group at Sembach, the 586 TMG at Hahn Air Base, and the 585th TMG at Bitburg Air Base.

The 587th TMG is presently transitioning to the **Martin** TM76 *Mace* as replacement for the Martin TM61 *Matador*. The 586th and 585th will eventually transition from the *Matador* to the *Mace*, but dates for conversion have not been announced.

No plans have been announced for additional U.S. Air Force tactical guided missile bases in Europe.

• **Willing Suppliers**—Publicly, at least, there are no plans for the U.S. Armed Forces or any of the NATO nations receiving U.S. missiles to have support equipment manufactured in Europe. The main reason is that it would be too costly to produce the small quantities required to support existing facilities.

Nonetheless, the European aircraft industry, which is suffering badly from lack of orders, would welcome an opportunity to get into this field. Industry officials hope the offshore procurement program may be extended to this area.

They point out that contracts such as those involving the production of F-86s by Italy's **Fiat** and F-84 spares by France's **Sud Aviation** proved that the European industry can do a good job in building U.S. equipment under license.

Officials at Chateauroux believe that European industry may get involved with U.S. missiles first in the overhaul and maintenance field, rather than in license production. At the moment the USAF has contractors in most of the countries of Europe overhauling and maintaining piloted aircraft, their engines and components. This system has saved the U.S. taxpayer money as well as giving needed work to the European aircraft industry. Its exension to the missile field would be logical.

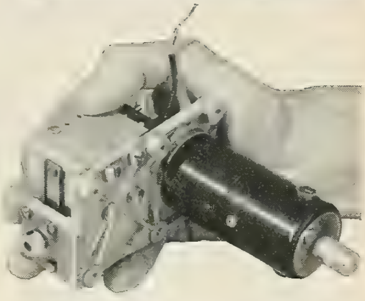
New Missile Buildings Rise on Both Coasts

New buildings are rising for missile makers on the East and West Coasts. **Lockheed** has signed a construction contract for the first $2,500,000 unit of its new electronics division headquarters at Newport Beach, Calif. **Microwave Associates Inc.** has begun construction of a $750,000 expansion of its facilities in Burlington, Mass. And **Rantec Corp.** has broken ground for a $100,000 building, the first stage in a three-year expansion of its Calabasas, Calif., plant.

Puget Sound Bridge and Dry Dock Co., Seattle, a wholly owned Lockheed subsidiary, and **Diversified Builders Inc.,** Paramount, Calif., will be joint general contractors on the Lockheed job. It provides for about 100,000 square feet of construction, which will be the nucleus of a major scientific and production center on a 200-acre triangle near Upper Newport Bay. The schedule calls for occupancy late next summer.

VAPPI Construction Co. of Cambridge, Mass., will build the Microwave addition, scheduled for completion next spring. A new 17,000-square-foot wing will be added to the building housing the firm's semiconductor and tube operations, and a new 32,000-square-foot structure will be built for research and production of microwave radar components.

Electro-Mechanical CLUTCH and BRAKE ASSEMBLY



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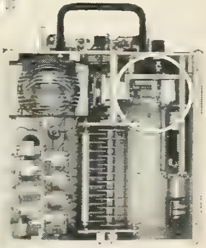
Uses two F & W drives as circled. When frequency is selected motor is actuated and first clutch engages driving crystal drum to proper crystal. Clutch releases and brake holds setting.

Second clutch engages, driving tuning unit to proper tuning point. Clutch is then deactivated and brake holds entire mechanism.

Motor coasts to a stop.



Aerocom Tuner
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PROBLEMS OF SATELLITES AND SPACE OPERATIONS; Lecture series, Office of Naval Research, April-July 1958. Order PB-151410 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 111 pps. $2.50.

The lectures, presented to the ONR research staff and representatives of other Government agencies from April to July 1958, concern problems associated with manned satellites and space operations.

Talks were given by Donald H. Menzel, director of the Harvard Observatory, on problems of the space age; Homer E. Newell, Jr., superintendent of the Atmosphere and Astrophysics Division, Naval Research Laboratory, on objectives of space research; Gerald M. Clemence, scientific director at the Naval Observatory, on Space navigation and celestial mechanics.

John P. Hagen, director of Project Vanguard at NRL, on satellite tracking; N. Whitney Matthews, head of the Applications Branch, Solid State Division, NRL, on satellite payload optimization; Fred L. Whipple, director of the Smithsonian Astrophysical Observatory, on astronomy and space operations.

Jerome B. Wiesner, director of the Research Laboratory of Electronics at MIT, on space communications; and Hugh L. Dryden, deputy director of the National Aeronautics and Space Administration, on the work of the NASA.

HIGH TEMPERATURE PRINTED CIRCUITRY; G. H. Young, C. H. T. Wilkins Etc. Quarterly report No. 4 on Computer Components Fellowship No. 347. Order PB 136 579 from Library of Congress, Photo-duplication Service, Publications Board Project, Washington 25, D.C. 41p. Microfilm, $3.30, photocopy, $7.80

Findings of the program on high temperature printed circuitry are summarized briefly, and the several techniques for circuit fabrication are evaluated in the light of the 200°C temperature specification for this year and the 750°C specification for the coming year.

The conductivity of silver enamels has been found to remain high with silver contents as low as 26%. Platinum resistor films were found to have a linear temperature coefficient of resistance from 28 to 500°C, with a change in resistance of plus 18% over this temperature range.

Boron carbide thermistor films are stable in air above 750°C, but crack when temperature cycled between 200 to 300°C. Silicon carbide and zirconium carbide enamel resistor were successfully formed using suitable wetting agents.

Irreversible increases in resistance were observed in testing vacuum deposited gold-palladium resistor films to 500°C.

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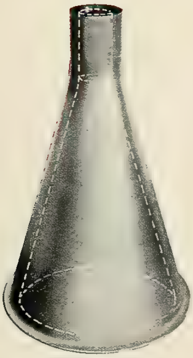
Forging of a Refractory Throat for Missile
Material: Tantalum 90%
Tungsten 10%
Outside Diameter of Large End: 6.25"
Height: 4"
Outside Diameter of Small End: 5.25"
Weight: 42.25 lbs.

Forging of Turbine Rotor Stub Shaft for Nuclear Jet Engine
Material: A-286 Steel
Outside Diameter of Cone End: 33.687"
Outside Diameter of Shaft: 10.375"
Height: 44.875"
Weight: 1150 lbs.



Forging of a J-93 Front Turbine Shaft for Aircraft Gas Turbine Engine
Material: Waspalloy
Diameter of Conical End: 23.38"
Diameter of Hub End: 6.50"
Length: 27.68"
Weight: 430 lbs.

Forging of a Liner — Exit Cone Missile
Material: Unalloyed Arc Cast Molybdenum
Diameter of Large Conical End: 10.50"
Height: 12.89"
Diameter of Small Conical End: 6.75"
Weight: 104.5 lbs.

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A simple method of attaching lead wires to high temperature printed ceramic circuits using properly formulated enamels is also described.

EFFECTS OF BRIGHT POINT LIGHT SOURCES ON LOW LEVEL IMAGE ORTHICON DETECTORS; R. K. H. Gebel, WADC. Order PB 151587 from OTS, U.S. Department of Commerce, Washington 25, D.C. $.50.

Treated in this pamphlet are causes and corrections of the high brightness point source effect in orthicon tubes.

The conclusion was reached that halo and ghost produced by redistribution of secondary electrons in a military tube should be avoided if possible, since they appeared to show nonexistant targets. The present glass target plate should be replaced with a faster target having insulated metal plugs.

By incorporating this assembly in an isocon arrangement no "overfloating" of the charge which results in the loss of low intensity background information, because of high intensity point sources, should occur.

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TRACKING OF A MOVING TRANSMITTER BY THE DOPPLER EFFECT; Thomas Skinner. Order No. PB 139 909 from Library of Congress. Photo duplication Service, Publications Board Project, Washington 25, D.C. 23p. microfilm, $2.70, photocopy, $4.80.

This report considers the feasibility of tracking a moving transmitter, in particular, an artificial earth satellite, by measurements of doppler shift only.

Although it is shown to be possible to track a transmitter moving on an arbitrary course, unless sufficient prior knowledge of the motion is available the computational procedures are impractically involved.

With this in mind, two restricted types of motion are considered, constant velocity and two-body central field motion. The former is analytically very simple, and the latter is a reasonable approximation to the motion of an artificial satellite.

AN INVESTIGATION OF THE MECHANICAL PROPERTIES OF CERMETS AS RELATED TO THE MICROSTRUCTURE; Ira Binder and Robert Steinitz. Order No. PB 151 722 from OTS, U.S. Department of Commerce, Washington 25, D.C. 95 p. $2.25.

Seven different test groups were formulated, using 60 TiC-40 Ni as the test material, comprising changes in original particle size, processing procedure, and controlled binder addition.

Each test group was heated in seven different fashions. Each test batch so obtained was tested for physical properties and its microstructure was investigated. The microstructures were correlated with changes in physical properties.

OXIDATION OF EXPERIMENTAL ALLOYS; Joseph C. Richmond and H. Richard Thorton. Order No. PB 151741 from OTS, U.S. Department of Commerce, Washington 25, D.C. 19p. $.50.

Tests were conducted on five newly devoloped high-temperature alloys to determine their oxidation resistance.

Measured was the average depth of external oxidation and maximum depth of oxide penetration on specimens placed under stress in air under varying temperature conditions for an equal time.

The changing weight of samples oxidized in air at high temperatures was continuously recorded for up to 100 hours. All of the alloys conformed reasonably well to the parabolic rate law in the weight-gain oxidation tests.

RADIO TRACKING OF EARTH SATELLITES; Pickard and Burns, Inc. Order PB 139915 from Library of Congress, Photo Duplication Service, Publications Board Project, Washington 25, D.C. 141p. microfilm: $7.20, photocopy: $22.80.

This report includes; Satellite orbital data, application of orbital data, instrumentation for doppler frequency measurements and analysis, laws of satellite motion, energy relations and orbital velocity, and perturbations of satellite motion.

Nerve Cell Research Urged for 'Decision-making' Guidance

Armed Forces Chemical Association also hears of need for work in dielectric behavior in space

by John Judge

WASHINGTON—Living nerve cells may yield clues to developing a bio-electronic space vehicle guidance system with "decision-making" capability.

Alton E. Prince, a chemist in the Wright Air Development Center materials laboratory, said intensive nerve cell research is indicated as the result of the recent discovery of the synthesis of "giant" protein molecules.

He told the Armed Forces Chemical Association 14th annual meeting that "with more knowledge concerning the molecular structure in the living cell, the synthesis of polymeric chains which would be responsive to an electrical signal, select the necessary information and make a decision. is a necessity." He believes such materials ultimately would find wide use in space guidance systems.

Prince said it can be anticipated that the fundamental aspects of space age chemistry will not change much from the present or the past. The products of space age chemistry will depend, as in the past, on the ingenuity of the scientists in their laboratories. It is certain that, in time, some of the laboratories will actually be space vehicles.

"It seems probable that there will be less room for the extreme individualist in a corner of a laboratory by himself, because teams of people with great differences in training and experience even now are required to solve existing problems. This is true because nearly half a lifetime is required to gain training and experience to formulate sound concepts for future needs," he said.

Another fundamental problem that can develop is that attempts will be made to place the new knowledge gained from space exploration into categories already established for our own little earth. It is believed that the exploration of the space and its contents will yield facts which do not at all fit into our preconceived, inherited and firmly established categories of the past, he added.

Need for increased chemical research in structural materials capable of functioning in an environment of 2000°F to 5000°F was stressed by Claude Kniffin of ARDC. He pointed out that few presently available materials are fully satisfactory, especially for extended periods of service. The day of the multiple use of single materials in aerospace vehicles structure is definitely over, said Kniffin, and the trend is toward composite items such as sandwich structures and surface coatings.

Future performance requirements envision temperatures up to 10,000°F and if these are to be met, progress must be made in two simultaneous yet slightly divergent directions. The materials themselves must be provided and the data currently available must be collected, evaluated, and disseminated so that more effective application can be made.

• **Vacuum research needed**—Much of the present knowledge of dielectric materials has been developed in the light of terrestrial conditions, reported Nelson A. Terhune of the Army Signal Research and Development Laboratories. But little is known about their behavior in outer space. Evaporation is greatly enhanced by the absence of atmosphere, said Terhune, and the material can be effected in two ways.

Ablation of the substance or a change in its composition due to the loss of a more volatile component may become serious in a relatively short time. And the other effects will be caused by the removal of the absorbed gases always present under normal conditions.

Dr. Wilbur A. Riehl of the Army Ordnance Missile Command called for new and improved corrosion inhibitors, compatible paints for marking and coating shipping containers and additives as partial catalysts in high-energy liquid fuels. The Army expert suggested the possible use of scavengers or "getters" in removing fuel contaminants.

• **Energetic binders**—Future research in high-energy solid propellant technology should be directed toward chemical reactions that produce low molecular weight gases at reasonable flame temperatures. Dr. Evan C. Noonan of the Naval Ordnance Laboratory said this path may produce delivered impulses in the neighborhood of 300 I_{sp} with solids.

He suggested that, due to the demands for high elongation at maximum strength for case bonded propellants, energetic binders might be substituted for part of the oxidizer in composite grains.

Martin Devine of the Naval Air Material Center reported new dry film lubricants have been developed which are stable through a temperature range of —300°F to 750°F. He said they will permit ball bearing lubrication for periods up to 240 hours.

The compounds, inorganic in nature, will function immersed in liquid oxygen. Based on their chemical structure, the stability in nuclear radiation and at low pressures should be satisfactory. It is anticipated that such lubricants will eliminate excess weight, increase reliability of operation and provide new mission capabilities.

Research in high-temperature plastics was discussed by Dr. Lewis W. Butz of the Office of Naval Research. He said program objectives include development of information concerning the range over which properties can be varied by changing the details of structure and the providing of new inorganic plastic compositions.

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—letters

Battery Omission

To the Editor:

It surprised us that your article "Batteries Retain Their Power Role" (M/R, Aug. 24) failed to mention our company as a leading manufacturer of nickel cadmium batteries. We probably have sold more (such) batteries, in a wider number of applications, in this country, than all the other . . . manufacturers combined.

NICAD developed and introduced both the pocket plate and sintered plate nickel cadmium storage batteries to the United States. We have sintered plate batteries in the *Tartar, Terrier* and Norair T-38 trainer as well as in "design in" phases of a number of missiles and other classified military projects. Our pocket plate batteries are used extensively in many military and nonmilitary applications, including missile ground support: DEWLINE, WHITE ALICE and USAF GLOBECOM installations. Nearly 1000 major U.S. merchant ships are equipped with NICAD batteries . . .

Ralph W. Gage
Sales Promotion Manager
NICAD Division
Gould-National Batteries, Inc.
Easthampton, Mass.

M/R apologizes for inadvertently omitting NICAD, decidedly a leading manufacturer in the battery field.—Ed.

Full Names in Future

To the Editor:

In M/R of Aug. 31, we noticed a misleading detail in your article on Avco's Dr. Arthur Kantrowitz. You say "a policy change after the war switched Avco to civilian-market emphasis and it acquired Bendix and Crosley. Largely because of distribution problems, Avco sold Bendix to Philco in 1956 . . ."

To the best of our knowledge, **Bendix Aviation Corp.,** as such, has never been any part of Avco Corp., by acquisition, agreement or any other means. It is true that Bendix Aviation and Bendix Washing Machine Activities were founded by Mr. Vincent Bendix, but at no time was there any connection between the two activities, due to the fact that Mr. Bendix had disassociated himself from Bendix Aviation Corp. prior to any interest on his part in the Bendix Washing Machine Activities.

We feel that your statement . . . incorrectly presents the present position in the aviation and missile fields enjoyed by Bendix Aviation Corp.

E. A. Carpenter
Marketing Manager
Special Products
Red Bank Division
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M/R regrets not specifying that the company involved in the acquisition was the firm now titled Bendix Home Appliances Inc.—Ed.

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ATLAS—RCA is Project Manager for the development, manufacture and product support of automatic checkout and launch control systems for the operational Atlas ICBM.

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people

DUNLAP

Dr. W. Crawford Dunlap, Raytheon Mfg. Co. scientist, has been named editor-in-chief of "Solid State Electronics," a new international publication dealing with transistors and other solid-state devices.

Dr. Dunlap, director of semiconductor research for Raytheon, is the United States representative heading a five-man board of editors from the United Kingdom, Europe, Japan, the Far East and one to be appointed from the U.S.S.R.

Prior to joining the company in January of this year, he was supervisor of solid-state research at Bendix Aviation Research Laboratory and a consultant and research physicist with General Electric Co.

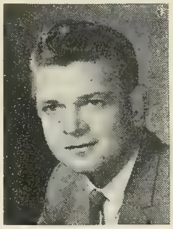
Frederick D. Dodge has been elected chief engineer of Minneapolis-Honeywell's Missile Equipment Division, designers and producers of missile launching and checkout equipment.

Prior to joining the division in 1958, Dodge held various engineering positions at Brown Instruments Division.

John N. Monroe, formerly president of Monroe Laboratories, has joined the Guided Missile Division of Firestone Tire & Rubber Co.

Monroe, a specialist in conceptual guidance and detection systems, stellar tracking and optics, previously was associated with Northrop Corp. and The Martin Co.

DODGE


MONROE

LEVESQUE

Russell J. LeVesque has been appointed manager of the Printed Circuit Department, Technical Products Division of Packard-Bell Electronics.

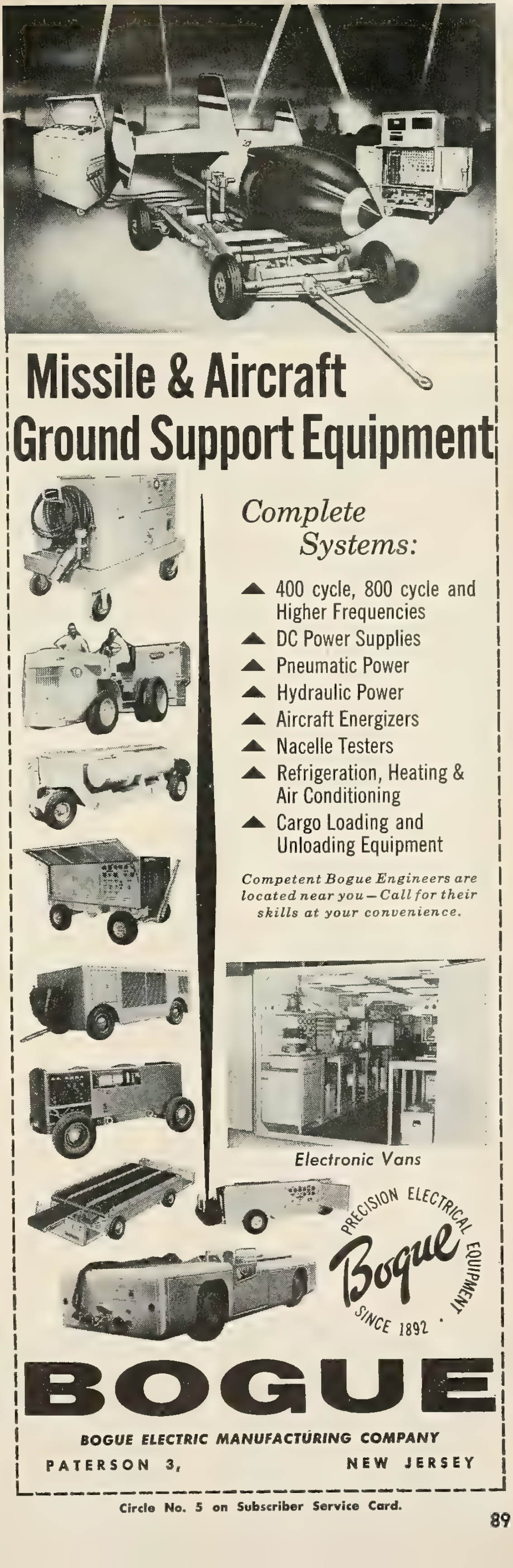
LeVesque has had more than 16 years experience in the electronics industry including ten years of supervision and design at Northrop, two years with North American Aviation as design engineer and electronic designer for two years with Hughes Aircraft Co.

Mrs. Donald R. Quarles, who has long been associated with aviation matters through her husband, the late Assistant Secretary of Defense, has joined FAA as Confidential Assistant to the Chief of Office of Public Affairs.

Thomas M. Linville, manager of the Research Operation Department of General Electric's Research Laboratory, has been named a member of the National Research Council and will represent the American Institute of Electrical Engineers in the NRC's Division of Engineering and Industrial Research.

LINVILLE

Linville, who joined GE in 1926 has served in his present position since 1953. He has specialized in design and development of motors and control systems, engineering administration, engineering education and holds seven patents.



Missile & Aircraft Ground Support Equipment

Complete Systems:

- 400 cycle, 800 cycle and Higher Frequencies
- DC Power Supplies
- Pneumatic Power
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- Aircraft Energizers
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Competent Bogue Engineers are located near you—Call for their skills at your convenience.

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BOGUE

BOGUE ELECTRIC MANUFACTURING COMPANY
PATERSON 3, NEW JERSEY

Circle No. 5 on Subscriber Service Card.

engine power
BY CATERPILLAR

THEY DEPEND ON CAT DIESEL POWER TO KEEP AIR FORCE ATLAS MISSILE ON TARGET

Calibration of the delicate electronic system of an Atlas missile requires a portable power source with unusually accurate control of voltage.

Down-range tracking stations need a power supply that can be depended upon in *any* emergency.

Both requirements are met by Caterpillar Diesel Electric Sets. Caterpillar Diesel Engines in these sets are extremely efficient 4-cycle engines which operate on any fuel from JP-4 through No. 2 furnace oil. They start easily, pick up load quickly and can be maintained and operated by unskilled personnel. Parts—and service—are available all over the Free World.

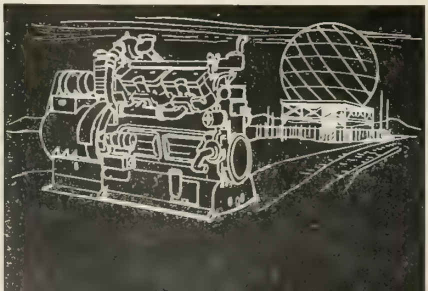
These are some of the reasons why you will see so many Caterpillar Electric Sets used for primary and standby power at our missile bases and other military establishments. They are used to supply power for testing, for starting jet engines, for radar warning systems, for lighting, heating and other base living facilities.

Free booklet. Get the full story on the advantages of Caterpillar Diesel Electric Sets. Write to Engine Division, Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co

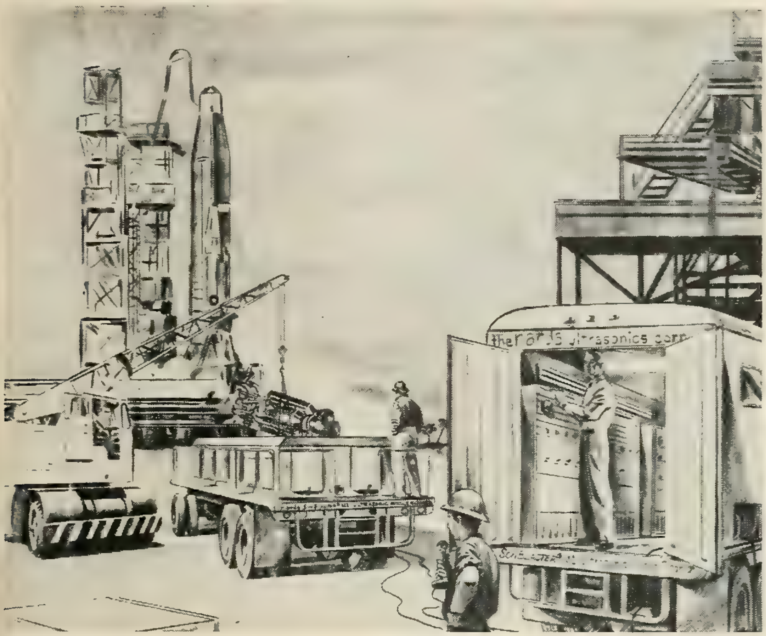
At Edwards Air Force Base in California, power for testing the precision electronic control circuits of the Atlas missile is supplied by two Cat D375 Diesel Electric Sets. They meet the triple requirement of portability, dependability and accurate control.

JET ASSIST. Caterpillar Portable Electric Sets supply dependable power for starting jet engines and for calibrating control systems.



ALONE. Without benefit of people to look after them, Cat Electric Sets furnish power for gap filler sites in our aircraft warning system. They are used at larger bases, too.

ENDURANCE. At Air Force Bases in the Atlantic, Cat Electric Sets have run over 20,000 hours without overhaul, while supplying 68,000 kwh a month.



Mobile Missile Cleaner Available

The **Narda Ultrasonics Corp.** recently introduced the new M-1 Ultrasonic Missile Cleaner—a fully self-contained mobile missile cleaner for use at launching pads and at missile assembly plants.

The flat bed trailer is 24 feet long and supports a transducerized tank measuring 20 feet by 6 feet by 3 feet deep. This tank requires 30 kw input.

The transducers are paired in 1 kw modules for easy field maintenance and replacement. The trailer is towed by a power tractor of the cab over the engine type.

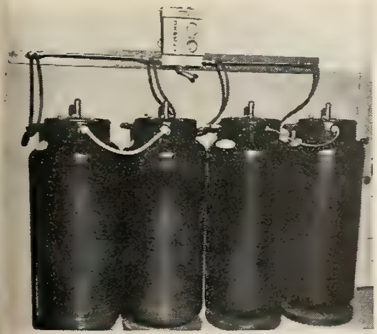
Twelve of Narda's G-25001 generators are installed in the rear of the air-conditioned van. The van is equipped with all of the necessary cables and maintenance facilities.

In addition to missile cleaning equipment, Narda has developed the SonBlaster DVC—3000 "Jupiter," a two-stage ultrasonic vapor degreaser.

Circle No. 225 on Subscriber Service Card.

LOX Manifold Features Automatic Change-over

Liquid oxygen cylinders can now be manifolded with a new manifold introduced by **Linde Co.,** Division of the **Union Carbide Corp.**



Used with four Linde LC-3 liquid oxygen cylinders, the new Oxweld M-40 provides an uninterrupted supply of 12,000 cubic feet of oxygen. More than 48 conventional high-pressure cylinders would be needed to supply the same amount of oxygen. And, the new unit occupies only a fraction of the space required for an equivalent high-pressure cylinder supply.

The new manifold is expected to find widespread use as a replacement for many existing systems of high-pressure cylinder oxygen supply.

Automatic change-over from one bank to another is an important feature of the new Oxweld M-40. As the supply in one cylinder bank is depleted, the manifold automatically continues to supply oxygen from the other bank. This feature provides a continuous, uninterrupted supply which is important in many industrial applications and vital in hospital use.

The new Oxweld M-40 manifold is flexible. Standard models are supplied for use with four or two Linde LC-3 cylinders arranged in two banks.

The M-40-2 two cylinder manifold is designed for hospital service. A five-cylinder emergency standby manifold for gaseous cylinders and a junction box assembly for connecting both manifolds to a hospital piping system are available for use with the M-40-2 manifold.

Circle No. 226 on Subscriber Service Card.

Exhibit Demonstrates CO$_2$ Liquid Equipment

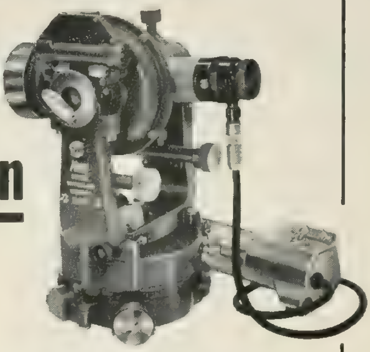
Pure Carbonic Company and **Wyle Manufacturing Corp.** cooperating on a project to show the advantages of carbon dioxide (CO$_2$) liquid as a cooling agent for environmental testing have developed a traveling exhibit mounted on a 40′ flatbed trailer to demonstrate products directly at the plant sites of missile/aircraft components manufacturers.

Pureco, a division of **Air Reduction Company, Inc.,** is a major nation-wide producer and distributor of CO$_2$ and CO$_2$ supply systems, and Wyle is a leading manufacturer of environmental equipment designed to use CO$_2$ liquid for low temperatures.

The CO$_2$ liquid for the demonstrations is provided in two storage units: a stationary six-ton unit and a half-ton mobile unit. These units, typical of those made available by Pureco, provide storage without loss over an indefinite period.

CO$_2$ liquid is piped from the storage units to a Wyle portable servo temperature conditioning unit. This unit

← Circle No. 3 on Subscriber Service Card.



INERTIAL GUIDANCE
Represents one of many applications of
Autocollimation
to solve Alignment Problems of a highly precise nature.

The KERN DKM2

When equipped with the new No. 356 Autocollimating Eyepiece, this famous one-second theodolite has a total magnification of 23x and an operating range from zero to at least 100 feet for autocollimation.

Write for technical data and specifications. No. 12

Kern SWISS

The FINEST in SURVEYING EQUIPMENT
KERN INSTRUMENTS INC.
120 Grand St., White Plains, N. Y.

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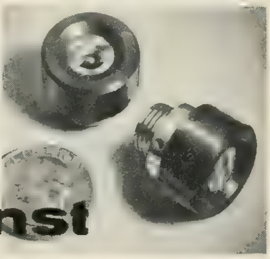
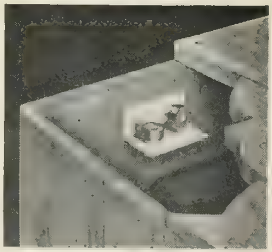




How to check against shipment damage to sensitive equipment

V-DOT visibly shows transit damage. DEPENDABLE, SIMPLE, TAMPERPROOF, ECONOMICAL—

Inertia Switch's V-Dot Indicators instantly reveal damage-causing shocks to shipments. This is especially important for precision equipment and delicate instruments.

The V-Dot Indicator has a single moving part, a steel ball, held in position by a magnetic force exactly set and sealed to withstand normal handling and shocks up to a predetermined standard. Available in any desired setting from 5 to 75 gs. Any damage-causing shocks will dislodge the ball from its center position. The indicating ball cannot be moved again until the seal is broken, the case opened and the ball re-set by hand. It cannot be accidentally or intentionally triggered by tipping or maneuvering.

V-DOT INDICATORS are small and light enough to be mounted unnoticed on equipment or in containers, packing cases and crates.

Write, wire, phone, TODAY, for complete descriptive brochure MR 1059 and prices.

INERTIA SWITCH Inc.
Packaging Protection Division
311 West 43rd Street, New York 36 • JUdson 6-5880
U.S. Patents issued and pending

Circle No. 6 on Subscriber Service Card.

converts simple insulated enclosures of virtually any size into automatically controlled high/low temperature chambers. Temperature range is −100°F to +400° F, and any selected temperature is automatically held to within plus or minus 2° F. Temperature conditioned atmosphere is circulated through test enclosures via six-inch diameter fiber glass insulated hoses.

One of the insulated enclosures with which the temperature conditioning unit is demonstrated is a chamber fitted over an oil film vibration slip table to provide temperature environments during vibration testing. The slip table, recently placed on the market by Wyle, consists of a large granite block with an extremely flat, highly polished top surface. A slip plate, mounting the test specimen, is placed here. The flat surface holds the vibration accurately in one plane, virtually eliminating cross-talk problems.

To show the use of the temperature conditioning unit with large test chambers, an end section of one of Wyle's radically new foam-insulated, weatherproof walk-in chambers has been fitted with special doors and instrumentation, permitting demonstrations of the rapid temperature pull-downs possible with Pureco CO_2 liquid.

Also included in the exhibit is a Wyle chamber which features self-contained temperature control and utilizes CO_2 liquid by direct injection into the chamber.

Recent breakthroughs in equipment design, together with today's wide availability of CO_2, make this medium one of the most practical and efficient for low temperature tests. Through the use of the trailer exhibit, the companies intend to make potential users aware of the full potentialities of CO_2 as a cooling agent.

Circle No. 227 on Subscriber Service Card.

Homing Devices Improved By Refrigerant Spray

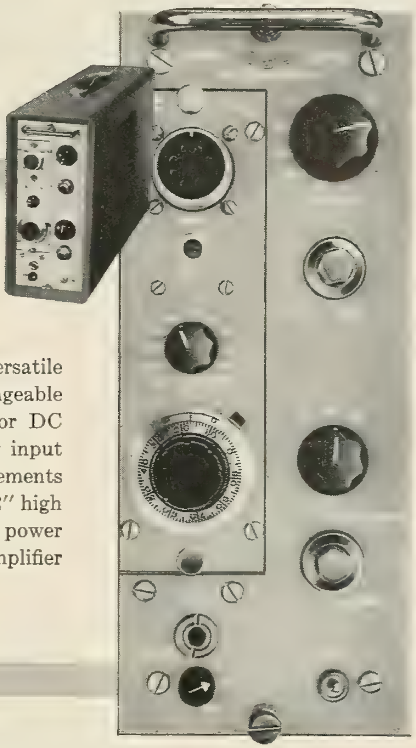
Sensitivity of "homing" devices in the guidance system of missiles and rockets is being improved by spraying "Freon" refrigerant into an electronic eye no larger than a thimble, to maintain its temperature at a frigid 114 degrees below zero. The refrigerant is manufactured by the **E. I. DuPont de Nemours.**

Heart of the electronic eye is a sensitive deposit of photo-conductive lead sulfide, lead selenide, or lead telluride—not much larger than the head

LOW LEVEL INPUT AMPLIFICATION

- ***1,000,000:1 rejection ratio at 60 cps***
- ***floating input***
- ***isolated output***

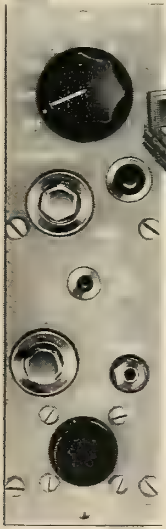
IN 2 NEW SANBORN CHOPPER AMPLIFIERS

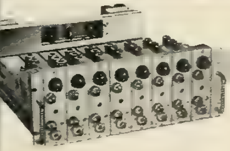


INDIVIDUAL SET-UPS

portable, self-contained unit amplifier

The Model 350-1500 Low Level Amplifier provides extremely versatile measurement of low level signals through use of two interchangeable plug-in circuits — one for thermocouple applications, another for DC strain gage work (other plug-ins now in development). Floating input and isolated output make the 350-1500 useful when signal measurements are made in the presence of large ground loop voltages. The 10-1/2″ high x 4-3/16″ wide 350-1500 may be used individually with its own power supply to drive a 'scope, meter, optical element, etc. or as a preamplifier in 6- or 8-channel 350 series recording systems.





MULTI-CHANNEL INSTALLATIONS

8-unit 7″ high modules for "850" series direct writers

Compact Model 850-1500A Low Level Preamplifiers are economical, space-saving units for large installations such as aircraft and missile development and test facilities where many recording channels are used to monitor strain gage and thermocouple outputs. Required 440 cps chopper drive voltages can be supplied for up to 16 channels with the *Model 850-1900 MOPA.*

SPECIFICATIONS

	350-1500	850-1500A
Sensitivity	20 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X2000 attenuator	100 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X200 attenuator
Input	Floating, can be grounded	
Input Impedance	100,000 ohms	200,000 ohms
Output	Floating or grounded (independent of input)	
Output Impedance	350 ohms	
Output Capabilities	±2.5 volts across 1000 ohm load	
Bandwidth	DC – 100 cps (3db)	
Linearity	±0.1% of full scale	
Common Mode Performance	120 db for 60 cps and 160 db for DC with 5000 ohms unbalance in source	
Noise	2 uv peak-to-peak over a 0 to 100 cps bandwidth	
Drift	±2 uv for 24 hours	
Gain Stability	±0.1% for 24 hours	

(specifications subject to change without notice)

Complete specifications and application data are available from Sanborn Sales-Engineering Representatives in principal cities throughout the United States, Canada, and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Mass.

Circle No. 4 on Subscriber Service Card.

precision mercurial

BAROMETER — MANOMETERS

Servo or Manually Operated Pressure Controller Available

Measures Absolute or Differential Pressures

Primary Standard Barometers Available

Features Available

Ranges: 0-31", 0-62", or 0-105" inches of mercury.

Temperature and Gravity compensated.

True pressure readings with accuracy guaranteed to .02% of full scale.

Visual sighting or Photo Electric Scanner which indicates pressure changes of less than .0004 inch of mercury.

Stop-bar mechanism for production testing at predetermined points.

Choice of scale graduations: inches, millimeters, millbars, or altitude.

Used by the U. S. Air Force and leading manufacturers where precise instrument calibration is necessary.

31" Type A-1 Barometer

For more information or special problem application call or write.

THE HASS INSTRUMENT CORPORATION
6173 BRANCH AVENUE • HIckory 9-5454 • Washington 23, D C.

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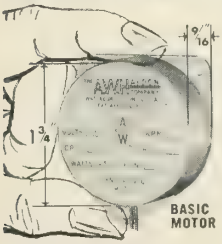
ANOTHER FIRST . . .



BASIC MOTOR

THE ONLY *Electro-Reliable* A.C. TIMING MOTOR

Thinner . . . Quieter . . .
More Reliable . . . More Versatile

FINGER-THIN . . .
Only 9/16 Inches Short . . . Only 1¾ Inches in Diameter . . . very compact . . . reduces the size of your equipment.

WHISPER-QUIET . . .
Strictly an electrical motor . . . practically noiseless . . . no rattling of gears or ratchets.

HIGH TORQUE . . .
¼ oz. inch at the rotor with an instantaneous start and stop . . . requires only 2½ watts . . . can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY . . .
Longer life . . . no one-way gears or ratchets to fail . . . provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard; 25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

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Send for Special Illustrated Bulletin AWH MO-806

The A. W. HAYDON Company
231 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

WITH INTEGRAL GEAR TRAIN

Circle No. 7 on Subscriber Service Card.

of a pin. This is mounted in the nose of the missile or rocket and performs much like a human eye, scanning the area ahead of the weapon.

In operation, a small electrical current flows through the lead compound. Because it is photo-conductive, its impedance or electrical resistance varies with the quality and amount of light to which it is exposed.

When infrared rays—from the exhaust of an enemy plane ahead of the missile, for example—pass through the protective window of the scanning eye to the lead compound, they cause a voltage change across the cell.

This minute change then can be amplified in the electronic equipment to which the cell is attached, to control mechanical energy to operate various parts of the weapon's guidance system so that it automatically "homes in" on the target.

Spectral response and sensitivity of the lead compounds vary with the temperature at which they're held, with both increasing at lower temperatures, and that's where "Freon" refrigerant enters the picture. A simple capillary tube jets a controlled amount of "Freon" into the thimble-size sensing unit. As the refrigerant gas expands it has the ability to absorb large amounts of heat from the lead compound and maintain its temperature at a pre-determined level—114 degrees below zero in the case of one unit using "Freon-13" monochlorotrifluoromethane. A variety of "Freon" refrigerants, each with a different boiling point, offers guidance system designers a wide choice of operating temperatures which can help adjust the spectral response of the lead compound to desired levels.

Although three types of energy are involved (light energy received through the scanning eye, being converted to electrical energy in the electronic components, then to mechanical energy in the power guidance system), response of the entire guidance system, when properly adjusted, is almost instantaneous. In fact, its "quick as a wink" action might be likened to the human body's reaction to a sudden flash of light. Here the eye transmits the increased light intensity to the brain, as electrical signals which are converted into mechanical energy to cause the eyelid to blink or close. The principal difference is that the mechanical "eye," instead of trying to shut out the light, just opens wider to "home in" on the target.

Aside from its cooling advantages, "Freon" refrigerant is particularly adaptable to use in such complicated electronic equipment because it is nonflammable, nonexplosive, noncorrosive to metals and other materials used in construction of the delicate parts, and has outstanding electrical properties.

Circle No. 228 on Subscriber Service Card.

Charge Control Unit Extends Battery Life

A new, completely automatic unit just introduced by the **Exide Corp.** helps to prolong the high-capacity working life of electric industrial truck batteries by providing proper change control.

Insuring a full-charged battery for peak truck performance on every shift, the new MP-3 Exide Charge Control Unit also eliminates the danger of overcharging the battery.

The MP-3 automatically controls the battery charging equipment as it brings the battery to a full state of charge, and then automatically terminates the charge.

Designed to control both regular daily charges and weekly equalizing charges, the MP-3 requires no attendance or resetting, regardless of the length of the normal charging time.

Interconnected with the charging equipment, the MP-3 initiates the charging process when the control indicator of the electric timing switch is dialed. A unique spring-pin metal stop above the control indicator on the door of the case makes it simple to pre-set the unit for a normal three or four-hour daily finishing charge. The stop also can be lifted to move the control indicator to the six or eight-hour weekly equalizing-charge positions.

Vital to the control function of the unit is the Exide TVR temperature-compensated voltage relay, mounted inside the case. When a battery on charge reaches 2.37 volts per cell at 77 degrees Fahrenheit, the relay operates to reduce the charging rate and/or start the electric timer. The bi-metal strip on the relay armature has differing expansion coefficients to compensate for temperature changes.

The MP-3 is designed to control modified constant potential battery charging. A control circuit also is provided in the unit to operate an external auxiliary relay when two-rate charging is used.

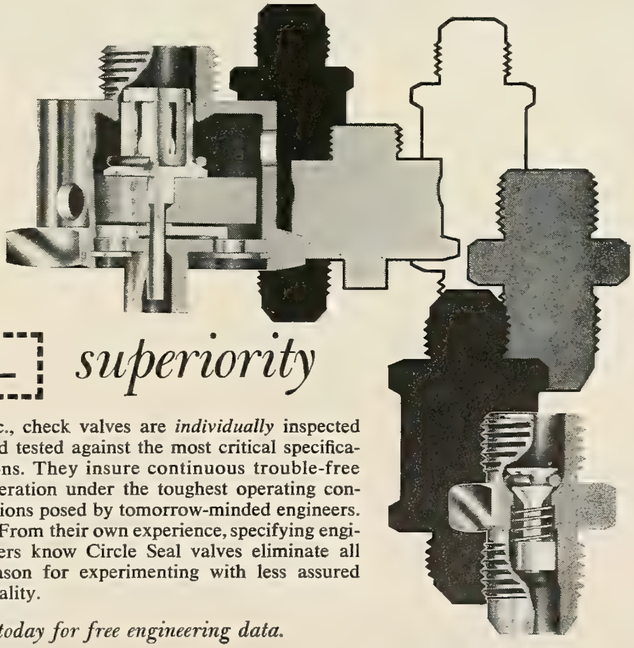
The Exide unit can be mounted readily with two screws or bolts in a vertical position on the charger or on a wall. Lead-in wires from the charger can be pulled inside the case and connected to the terminal strip after the unit is mounted. The vital components can be removed easily and replaced without demounting the unit.

Assembled in a gray hammertone steel case, the MP-3 is 6¼ inches wide, 8-1/8 inches high and 4-1/8 inches deep. The control indicator extends 7/8

1,000,000 A MILLION

Check Valves are proving

CIRCLE SEAL *superiority*



Today, with the experience gained in manufacturing over one million application-engineered Circle Seal check valves, James, Pond and Clark, Inc. is unique in its ability to meet the newest, most critical check valve requirements.

Rugged, high quality Circle Seal valves are a product of the valve industry's highest standards of quality. At James, Pond and Clark, Inc., check valves are *individually* inspected and tested against the most critical specifications. They insure continuous trouble-free operation under the toughest operating conditions posed by tomorrow-minded engineers.

From their own experience, specifying engineers know Circle Seal valves eliminate all reason for experimenting with less assured quality.

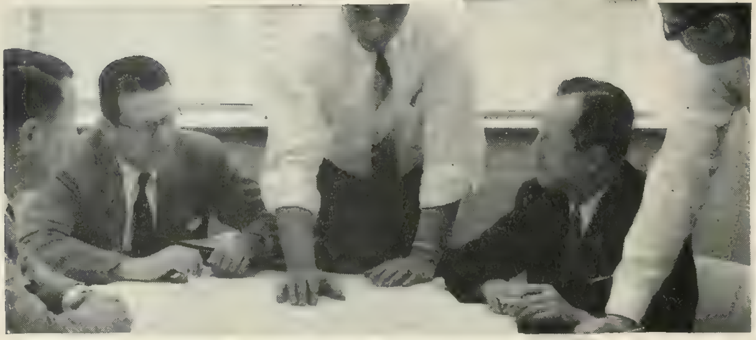
CIRCLE SEAL
precision valves

Please write today for free engineering data.

JAMES, POND & CLARK, Inc.
2181 EAST FOOTHILL BOULEVARD, PASADENA, CALIFORNIA

Circle No. 10 on Subscriber Service Card.

Breaking
Tradition
To Find
A Better
Solution—
Faster



Practical and economical answers to fluid handling problems help you get your project out on time

Quite possibly, the solution to your fluid handling problem demands a completely new approach.

A lot of problems do.

That's why FRI engineers specialize in creative . . . imaginative thinking, as well as ordinary analytical methods of problem solving. This combination is utilized for you in finding a workable, practical solution . . . economically.

It may range from developing a complete system to merely adapting an existing piece of equipment. Either way, FRI knows from experience which way to go.

If your problem is in any way concerned with fast fluid transfer, you'll find it highly profitable to discuss it with FRI engineers. Why not write today for literature?

Flight Refueling, Inc.

FRIENDSHIP INTERNATIONAL AIRPORT • BALTIMORE 3, MD.

West Coast Representative: William E. Davis, Box 642, Inglewood, Calif.
Denver Representative: Price Engineering Sales Associates, Box 421, Littleton, Colorado
Circle No. 11 on Subscriber Service Card.

of an inch beyond the piano-hinged door.

MP-3 Exide Charge Control Units can be selected for charging specific-sized batteries ranging from 6 to 60 cells. They are available at low cost from the manufacturer of Exide-Ironclad and Exide-Powerclad motive power batteries.

Circle No. 229 on Subscriber Service Card.

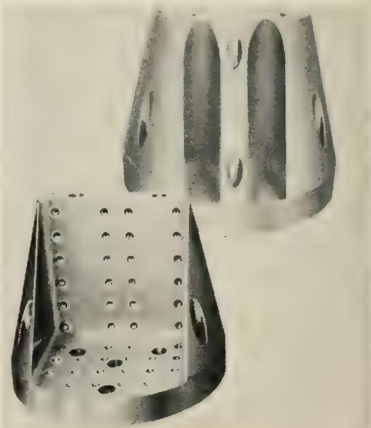
New Resonant-Free Test Fixture Developed

A new environmental test fixture that is resonant-free during normal use and may be used to mount test specimens during vibration, shock and acceleration tests has been designed by the **Avco** Research and Advanced Development Division.

The T-type fixture was designed to convey only the desired environment and is made of cast magnesium. It is capable of testing specimens in three mutually perpendicular axes, simultaneously. The fixture is essentially resonant-free below 2,000 cycles.

Use of the new rigid test fixture allows standardization of fixtures for vibration exciters, shock machines and centrifuges. The Avco scientists say that the fixture also has exceptional response characteristics in that the transmissibility factor does not exceed 1.10 up to 2,000 cps. This gives accurate transmission of input with no amplification.

Only minor adjustments are required for testing different specimens.



Components may be tested in each of three mutually perpendicular planes of motion by moving the test specimens to a different axis.

Called the Multi-purpose Environmental Test Fixture, it is available in a small size used with a 1,500 g-pound exciter and a larger size for use with a 5,000 g-pound exciter. The smaller size has a dimensional capacity of 6 x 6 x 4½ inches with a weight capacity of up to 6 pounds. The larger type has a dimensional capacity of 12 x 12 x 9½ inches and weighs up to 25 pounds.

Circle No. 230 on Subscriber Service Card.

Tiny Metal-to-Metal Seals Solve Hydraulic Problems

Temperature and pressure problems arising out of the increasing development of miniature hydraulic pumps and valves have been met by the production of a new series of tiny metal-to-metal seals by the **Harrison Manufacturing Co.**

Designated as Harrison K-Mini/Seals, the miniature seals are designed for applications requiring outside diameters smaller than ¾ inch. Standard sizes range down to ¼ inch.

Extensive testing indicate the seals are suitable for use in temperatures ranging from minus 300 degrees F. to plus 1200 degrees F. Zero leakage has been recorded in these tests at 6000 psig.

Like the other two series of seals, the K-Face/Seal and the K-Boss/Seal, the miniatures are re-usable, the re-usability factor depending upon the care and application of seating and re-seating.

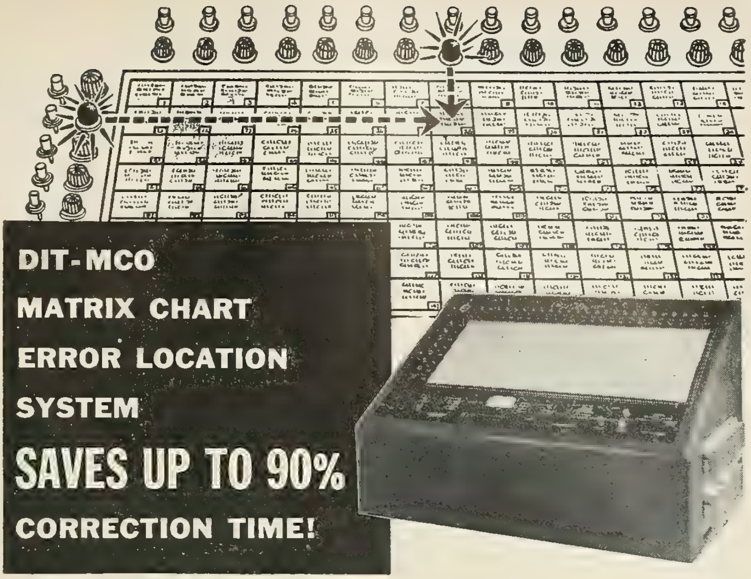
Circle No. 231 on Subscriber Service Card.

Rocker Arm Has Missile Qualifications

PITTSBURGH—A special stainless steel rocker arm is helping to make and fire missiles.

Automation in business and industry is also being made more feasible and more accurate through the adaptability of small but efficient switches of AM-350 stainless steel.

The stainless steel is used as an in-



DIT-MCO MATRIX CHART ERROR LOCATION SYSTEM

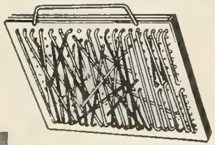
SAVES UP TO 90% CORRECTION TIME!

Pinpoints All Circuit Flaws Instantly...Plots and Simplifies Test Procedure...Provides a Permanent Record!

DIT-MCO's revolutionary Matrix Chart is the only error location device which puts all circuit information . . . errors, circuit numbers, type of flaws, etc. . . . directly in front of the operator of this Automatic Electrical Circuit Analyzer. It plots the entire test sequence and pinpoints every circuit flaw . . . instantly! Horizontal and vertical indicator lights cross reference to indicate the exact error location, circuit number and type of flaw. As errors are detected, they are recorded on the proper matrix square and the test continues.

Once the test sequence has been completed, all corrections are made direct from the Matrix Chart. This *group correction* feature saves up to 90% of error correction and/or interpretation time by eliminating time-consuming searches through complex manuals and wiring diagrams. After corrections have been noted on the Matrix Chart, it provides a complete record of test circuits, test specifications, instructions, results and modifications. This concise, understandable record improves interdepartmental communications and provides co-ordination through all stages of planning, production and maintenance. Non-technical personnel easily master operation of the Analyzer and use of the Matrix Chart System. The final Matrix Chart can follow the product for future overhaul and maintenance use.

DIT-MCO, Inc. employs an experienced staff of sales engineers in the field. Contact your field sales engineer or write for important facts about DIT-MCO Automatic Electrical Circuit Analyzers.



PLUGBOARD PROGRAMMING SPEEDS TESTING!

Jumper-wired plugboard programming permits use of simple, straightforward adapter cables. Circuit modifications never present headaches because all changes are easily made by re-jumpering the readily accessible plugboards.

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Circle No. 12 on Subscriber Service Card.

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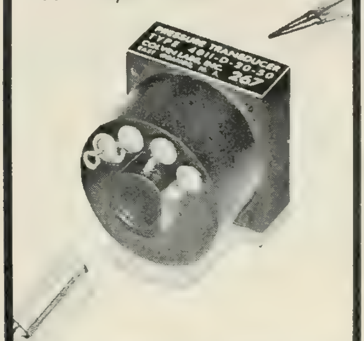
- Only one inch square – one inch long
- Withstands high vibration

35 G to 5000 CPS 0-3 to 0-400 psi
400 to 10,000 ohms



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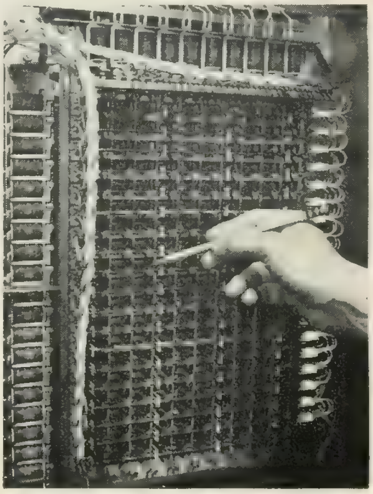
Find out how its use can be a time and cost saver while it up-grades your Quality Control. Just send for our "Borescope Catalog."

ENGELHARD INDUSTRIES, INC.
NATIONAL ELECTRIC INSTRUMENT DIVISION
92—21 Corona Avenue • Elmhurst 73, New York

Circle No. 15 on Subscriber Service Card.

tegral part of the crossbar switch made by **James Cunningham Son & Co.** This switch is a component of electrical computers and automatic programming equipment that requires high speed selection or scanning of multiple sources of information.

About 100 million cycles under load is demanded of the spring and rocker arm assembly of stainless steel.



This special steel is made by **Allegheny Ludlum Steel Corp.**

At the rate of 50 cycles per second, an individual crossbar switch can sample, select or translate data from as many as 1200 input points and relay the electronic information to reading or monitoring devices. The switches are often set up in relays to increase the number of input points.

Engineers designing the crossbar switch wanted a material that would work under greater stress loads than that previously used.

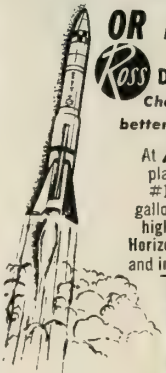
Circle No. 232 on Subscriber Service Card.

Gaussmeter Measures Flux Density

A new direct-reading gaussmeter, designed to measure direction and magnitude of flux density, has been designed and developed by **F. W. Bell, Inc.**

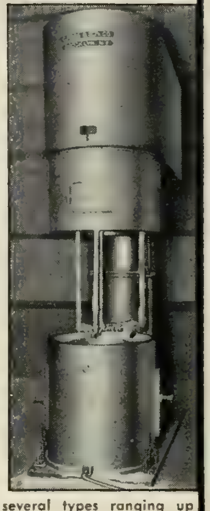
The new instrument is useful also in plotting flux paths, measuring flux leakage and performing other functions in the design and testing of electronic equipment. The unit has a carrying handle which doubles as a storage place for the probe, protecting the probe tip when not in use. A push-button on the probe itself facilitates use

FOR PROPELLANT---
OR PLASTISOL*



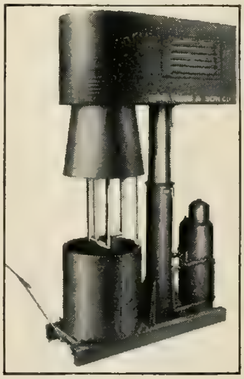
Ross DOUBLE PLANETARY
Change Can Mixers give better mixing in less time!

At Thiokol® solid propellant plant in Elkton, Md., this Ross #130CDM variable speed 100 gallon Mixer produces the same high quality mix as obtained in Horizontal Double Arm Kneaders, and in ⅓ the mixing time.



With no bearings or stuffing boxes in the product zone, stationary can, completely enclosed mix, and remotely controlled raising and lowering device, the Mixers are as safe in operation as they are efficient. Mixers have low original and maintenance cost, are easy to clean, and extremely versatile in operation.

Lower Illustration shows an 85 gallon #130-CDM Double Planetary Change Can Mixer furnished a leading concern for mixing plastisols of several types ranging up to 200,000 centipoises. Customer reports Mixer in operation 24 hours/day with mixing time per batch only 15-20 minutes; while the quality of mix and dispersion is so high that the final product is obtained in the Mixer alone — without further processing through a Three Roll Mill as was previously necessary with other Mixers.



Jacketed cans for heating or cooling material during mixing, dolly trucks, gates on cans for discharge, and vacuum tight covers can be provided.

*---or any other heavy paste material. On paints, inks, pharmaceutical products, caulking compounds, and other similar materials, the Ross Double Planetary Change Can Mixers mix and disperse up to 30 times faster than other Mixers.

Mixers available in 1, 2, 3, 4, 6, 8, 12, 20, 25, 65, 85, 125 and 150 gallon sizes. *Write* for complete information on these or other types of Ross mixing, grinding or dispersing equipment!

CHAS. ROSS & SON CO., INC.
Leading mfgrs. of wet or dry grinding Mills, Kneaders and Mixers of all types — since 1869.
148-156 (M) CLASSON AVE., BROOKLYN 5, N. Y.

Circle No. 20 on Subscriber Service Card.

by energizing the unit for quick readings.

Operating on the Hall Effect, the Bell Gaussmeter (designated Model 100) uses as its sensing element a thin wafer of high-purity indium arsenide with a temperature coefficient of 0.1%. The smallness of this element (.019″ thick and .125″ wide) permits insertion of the flat probe tip into very narrow air gaps. The active area of the sensing element is equal to a circle of .0625″ diameter. High gradient fields can thus be measured easily in confined spaces. The sensing element is non-magnetic and does not disturb the field being measured.

A convenient scale selector on the front panel gives gauss readings in three scales: 0 to 300, 0 to 3,000 and 0 to 30,000 gauss. "Balance" and "null" adjustments are not required on the front panel. The instrument will read DC flux in the presence of a strong AC field, rejecting the AC field and giving strong, continuous readings as long as the probe is held in a constant magnetic field. Measurements are indicated on a linear meter scale. No amplifier is used.

The power supply is a built-in 4½-volt battery, drawing current only when the push-button is depressed. A convenient cord hanger on the rear panel holds the 5-foot cord furnished with the unit. Dimensions of the unit are: 10-1/8″ wide, 4-3/8″ deep over all, and 7½″ high over all. The unit weighs 5 pounds. The finish is a dark grey baked-on enamel. Front panel trim is in anodized aluminum.

F. W. Bell, Inc., reorganized in June of this year and known formerly as American Electronics, Inc., announces also that probes and test fixtures for special applications are available on special order.

Circle No. 233 on Surbscriber Service Card.

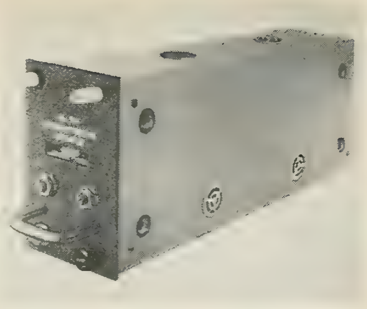
Solid-State Repeaters Aids Distorted Signals

The Trepac Corp. of America has announced a new line of teleprinter coupling repeaters designated the Diamond Trepac 560 Series.

Designed around the Trepac solid-state relay widely used for keying teleprinters, the new repeaters represent a simplification and operational improvement over the bulky, expensive, delicate repeaters previously used. The absence of moving parts (except for one mercury relay), electron tubes, and operational adjustments practically eliminates maintenance and repair problems.

The units operate from either 115-volt 60-cycle power or 12-14 volts DC, and require only 15 ma in "line-closed" condition. The repeater contains a rechargable standby battery which enables the unit to operate independently for three months after failure of the external power source. Location of the unit with respect to battery or ground terminations or any particular part of a telegraph line or loop is not critical.

Diamond-Trepac repeaters are said to be immune to many signal defects that incapacitate old-style units. The repeated signal emerges clear, clean and consistent (even when the input signal contains heavy asymmetric distortion) at modulation rates up to 200 bits per second. The repeater is remarkably immune to interference, change in signal levels, and load variation.



Complete service and production facilities for
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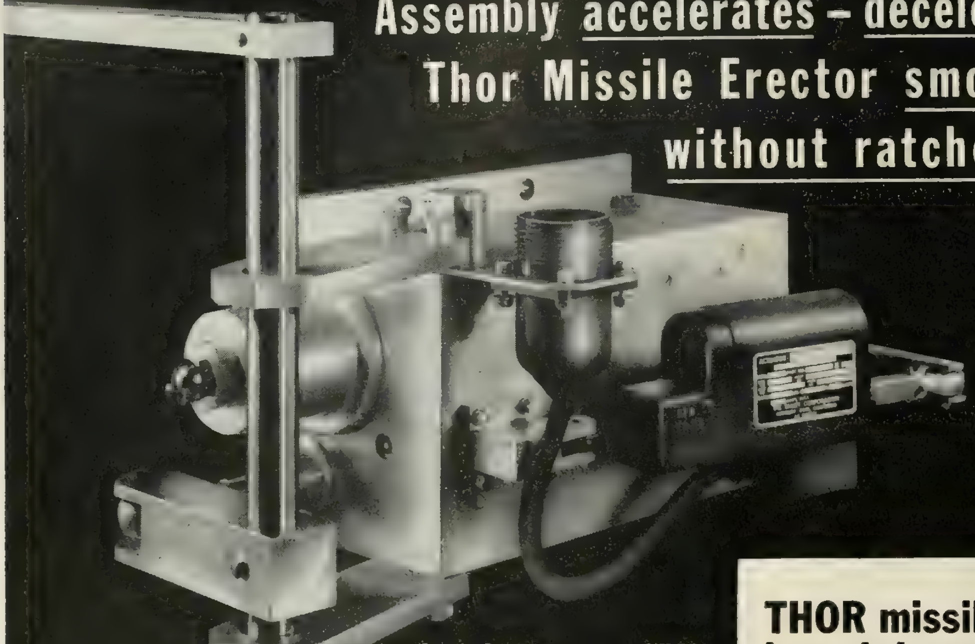
Circle No. 16 on Subscriber Service Card.

NEW VICKERS® Packaged Valve Assembly accelerates – decelerates Thor Missile Erector smoothly without ratcheting.



Operating Pressure	3400 P.S.I.
Proof Pressure	4500 P.S.I.
Burst Pressure	7500 P.S.I.
Temperature Operating Range	−15°F to +150°F
Filtration Nominal	10 Micron

Smooth control of the Thor erecting cylinder is accomplished by a new Vickers' packaged valve assembly. This assembly provides regulated acceleration-deceleration throughout the erecting cycle without compounding structural vibrations. Despite varying external loads and temperatures, firm positive control is maintained as the missile's center of gravity passes over the pivot point.

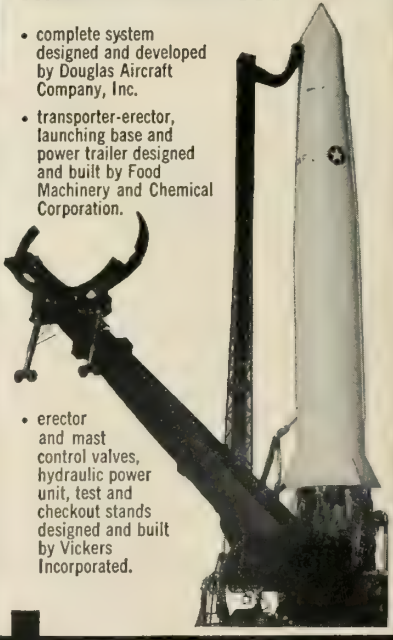
This "system engineered" valve is another example of the special ability of the Vickers Marine and Ordnance Department to solve difficult ground support problems. An integrated package, this new valve consists of a metering-type, modulating flow control that is pressure compensated for a fixed pressure differential. An integral, motor-actuated, 4-way directional control regulates starts and stops in mid-cycle.

Now in production, this valve can be used to control a broad range of accelerations, decelerations and overrunning loads merely by varying combinations of orifice sizes and spool configurations. Horsepower input can be adjusted to meet onsite power availability. Valve output can be controlled electrically, mechanically or hydraulically. Mounting flexibility permits valve installation directly on the hydraulic cylinder.

All units are factory pre-tested, interchangeable and require no external lines except to pump and tank. They are built to meet the most demanding reliability requirements.

THOR missile on launch base...

- complete system designed and developed by Douglas Aircraft Company, Inc.
- transporter-erector, launching base and power trailer designed and built by Food Machinery and Chemical Corporation.



- erector and mast control valves, hydraulic power unit, test and checkout stands designed and built by Vickers Incorporated.

If this valve offers a solution to your problems, call Waterbury, Connecticut, PLaza 6-3684 (TWX: WBY 160) for more complete information. Write for a free copy of Bulletin 5303 "Vickers Oil Hydraulics for Missile Systems."

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

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Circle No. 23 on Subscriber Service Card.

Each repeater is bi-directional. Pilot lamps indicate the direction of transmission. Repeater modules are 5¼″ high, 3¼″ wide, and 14″ deep. Five such modules may be mounted in a 19″ rack or seven in a 24″ rack, using standard accessory trays. Completely-wired bays, accommodating up to 50 units per rack, are available.

Portability, immunity from signal distortion or fluctuation, freedom from maintenance, and the standby battery feature make these repeaters ideal for use in remote, unattended locations. Their high speed capabilities assure their performance in the faster teletypewriter and data transmission circuits of the future.

All units are compatible with each other, and with existing standard equipment, and may be included in complex conference networks.

Circle No. 234 on Subscriber Service Card.

Thermometer Is Smaller Than Pencil Eraser

A resistance thermometer, half the size of an ordinary pencil eraser and designed for extreme accuracy and high temperature operation, is now available for immediate delivery from **Minco Products, Inc.**

The model S-22 provides reliable operation from –100°F. to +500°F. It has a resistance of 470 ohms at 32° F., which varies at the rate of about 1 ohm per degree F. The unusually small mass and size (.156″ dia. x .281″ long) results in rapid response to transients and changes in temperature. The tiny platinum sensing element is plotted for maximum environmental capabilities, dielectric and mechanical strength.

A unique attachment of the lead wires provides a minimum of 5 lbs. pull strength. The stainless steel case will withstand a minimum of 5 lbs. compressive force from a rigid load.

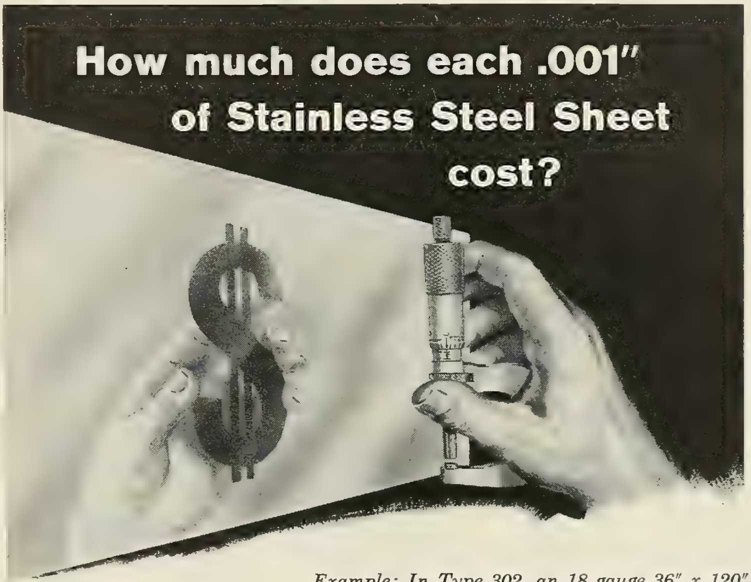
Calibration accuracies of plus or minus ¼%, ½%, and 1% are available from stock. Curves, points, and/or equations are available with each unit.

Circle No. 235 on Subscriber Service Card.

New Cycle Timer Is Totally Enclosed

Haydon Division of **General Time Corporation** announces the availability of an improved cycle timer known as Series AC-42, which is a totally enclosed, motor driven switching device for use in the control of vending machines, hand dryers, photocopying equipment, etc.

The timer, which the manufacturer describes as being extremely rugged and compact, repeats a set cycle or



Example: In Type 302, an 18 gauge 36″ x 120″ sheet has a base price of 52¢ per pound. In sheets of this size, each .001″ of thickness weighs 1.26 pounds per sheet. Thus, each .001″ of unnecessary thickness costs you at least 65.5¢ more per sheet.

On the surface this may seem insignificant, but it has a marked effect on the total price you pay for a given quantity of stainless steel sheet. With cost a factor, this can be important since stainless steel is purchased by weight.

Using the above example, a mere .001″ of unnecessary thickness costs you $20.76 more per ton. If you figure the maximum allowable gauge thickness variation of plus or minus (10%), you can readily see that the price you pay for overall sheet thickness could involve much needless cost.

Washington Steel has the equipment and the experience to produce MICRO-ROLD stainless steel to tolerances much closer than standard industry tolerances. Usually money can be saved by first selecting the minimum gauge that will serve the requirements of the application, and then specifying that the thickness be rolled to the light side of the gauge range. This specification involves no cost extra and is standard practice at Washington Steel. (If exact close tolerances must be guaranteed, there is a nominal additional charge.)

Consult your nearest MicroRold Stainless Steel Distributor. He will gladly show you how to save money on your stainless steel purchases.

Washington Steel Corporation
9-H Woodland & Griffith Avenues
Washington, Pa.

WASHINGTON STEEL CORPORATION MicroRold STAINLESS SHEET & STRIP

Circle No. 17 on Subscriber Service Card.

sequence of switching operations as long as the motor circuit is energized. If desired, the motor can be wired through switch contacts to limit rotation to one cycle. The wide choice of speeds and availability of "Torque-Rated" motors make possible many timing intervals.

The unit incorporates one SPDT switch and has a housing of molded phenolic, offering a rigid, dust tight construction that will assure reliable performance under adverse ambient conditions.

According to the manufacturer, all terminal and blade configurations are heavy gage spring brass without welded or staked joints. They are held positively in place by locating bosses and slots molded permanently in position, eliminating any shifting of blade position during installation and operation.

All series AC-42 Cycle Timers are equipped with amp "Ark-Les" quick disconnect type terminals for rapid, easy hook-up and ready replacement of or repair.

Circle No. 236 on Subscriber Service Card.

Good news for SPACE men with no TIME to wait!

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KEEPS YOUR SCHEDULE IN ORBIT
WITH IMMEDIATE DELIVERIES OF

IMPERVIOUS SHEATH
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HEAT, OIL & FLAME RESISTANT CONTROL CABLES . . . TWISTED PAIR SHIELDED TTRS CABLES . . . DBSP-TBSP-FBSP-MSS-MCOS-MMOP-SHFS-TTRSA. Furnished with Source Inspection Forms

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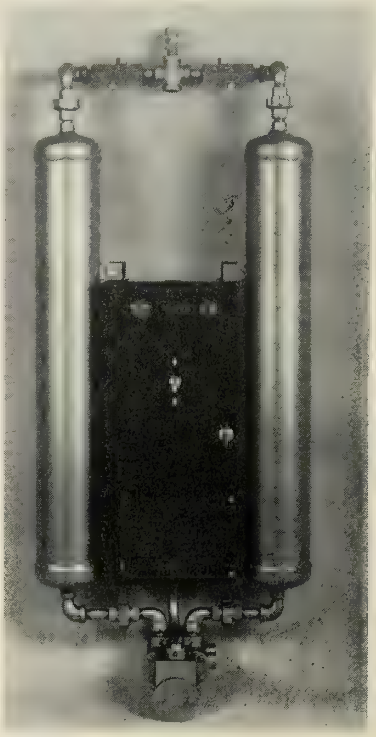
Circle No. 18 on Subscriber Service Card.

Automatic Compressed Air Dryers Now Available

Desomatic Products, Inc. are now in production on two sizes of small, inexpensive compressed air dryers for drying small quantities of compressed air, from 1 to 25 SCFM, with inlet pressures up to 125 psig and inlet temperatures up to 120°F.



This dryer is fully automatic, using a small amount of heat for reactivation. The components are simple—only two moving parts, a timer and solenoid type 4-way valve.

The desiccant towers are of the throw-away type and easily replaced by breaking couplings, loosening screw, pulling out plug-in heaters and replacing with a new tower. Heaters are permanently imbedded.

The desiccant and heaters will last several years under normal operation. There are built-in dust filters thereby assuring clean, dry air at dew points down to −60°F. or below.

Uses are dry air supply for controllers and instruments, precision air gauges, coaxial cables and wave guides, and small unit processes or machine operations where dry air is essential.

Circle No. 237 on Subscriber Service Card.

U. S. ARMY ANTI-MISSILE MISSILE

The man:

. . . a top missile scientist at White Sands, N. M., missile range where preliminary *Nike Zeus* tests take place. He is a key member of the highly specialized military-civilian team that is putting this agile anti-missile missile through its development stages.

When *Zeus* goes on active duty, it will follow Douglas *Nike Ajax* and *Hercules* missiles into service with the North American Air Defense Command. And it will be maintained by Army personnel assisted by Douglas field service men who have extensive experience in the *Nike* program.

The mission:

. . . anti-missile defense. *Zeus* will roar out from emplacements around cities and industrial and military areas to intercept approaching enemy ICBM's . . . or bombers.

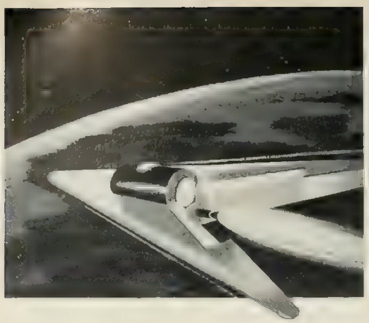
CLASSIFIED

The missile:

. . . *Nike Zeus* is being developed by Douglas under a Western Electric-Bell Telephone program. System will include electronic detection gear to pick up enemy ICBM's at extreme range and then guide *Zeus* out to destroy them. Vital statistics: CLASSIFIED.

Depend on **DOUGLAS**

The Nation's Partner in Defense



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Circle No. 19 on Subscriber Service Card.

propulsion engineering...

By M/R STAFF

Propulsion chemists . . .

and engineers can work faster, get more work done easier, thanks to a new shorthand developed for chemists and metallurgists by a U.S. Department of Commerce chemist. Gregg-type symbols represent all common words, arrangements and radicals, and much specialized terminology. The developer of the system, James Kanegis, is now Chief of the Chemical Section of Commerce's Office of Technical Services. Formerly he was a National Bureau of Standards metallurgist. Kanegis made news in 1957 when his 14-year-old daughter, Brenda, co-authored (with her father and Dr. Roger Gilmont) an American Chemical Society national meeting paper on cooking with glycerine.

Cryogenic, oxidize, catalyze, enthalpy . . .

are a few of the words of special significance to missile chemists that Kanegis has included in his chemical-metallurgy shorthand. There are also special symbols for these: organometallic, analine, pyrophoric, exothermic, modulus, stoichiometric, and over 1500 others. The system is based on a few fundamental symbols that cover realms of thought in chemistry. Specific words are modifications of the symbols. Therefore, it is not necessary to memorize the whole word list. There are symbols for all the important professional societies, and for the names of major chemical firms. Kanegis even has anticipated one very special need of the missile industry—he has included a curlicue to represent "Pentagon."

'Change of state,' and 1600 other phrases . . .

are symbolically represented for the convenience of propulsion chemists. Some of the others: Characteristic property, coefficient of thermal expansion, corrosion resistance, heat of combustion, nondestructive test, products of combustion, reaction kinetics, solid fuel, thermal expansion.

A short course in chemistry. . .

and one in metallurgy are presented in the Kanegis approach to teaching his chemical shorthand. This part is probably skipped by chemists, but is suggested by Kanegis as a means of upgrading clerical personnel to the point where they are much more valuable. The short courses, as they appear in a monograph Kanegis prepared some years ago (and has continually updated) will not make a chemist of a secretary. The subject matter is technical, but emphasis is on the forms and idiosyncrasies of technical expression. The form used is the Gregg shorthand, and Kanegis suggests prior study of conventional Gregg before tackling his chemical and technical shorthand. (He welcomes comments addressed to his home: 3907 Madison St., Hyattsville, Md.)

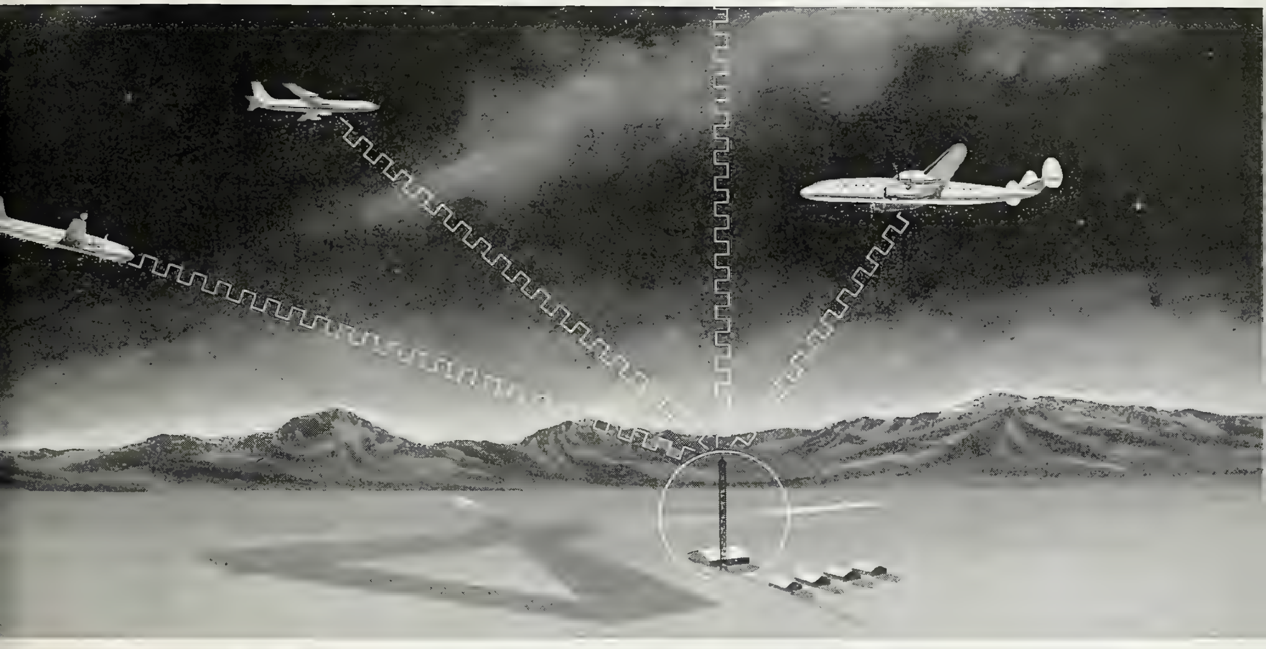
New missile fuel facilities . . .

are going on stream almost every month. Firms are breaking ground for others almost like clockwork. Here's the fall roundup. **Industrial Air Products Company's** LOX plant at Boise, Ida., is starting up. **American Potash & Chemical** is increasing capacity of its Aberdeen, Miss., sodium chlorate plant—a starting point for various perchlorate oxidizers. **Air Reduction Pacific Co.** (Air Reduction Co., Inc.) expects to have its 30-ton-per-day LOX and nitrogen plant in operation at Richmond, Calif., late this year. **Olin Mathieson** still is in the missile-aircraft picture despite Air Force high-energy fuel cancellations—O-M is opening up new facilities at Brandenburg, Ky., for propylene oxides and glycols, starting points for many fuel chemicals. **American Potash & Chemical's** lithium chloride facility at Henderson, Nev., is on stream—much of the output can go into lithium perchlorate, super oxidizer in solids.

new wings for words

AGACS

pronounced "AJAX"



AGACS, Experimental Automatic Ground/Air/Ground Communication System is a new concept in Air Traffic Control Communications to meet the accelerated pace of increased air traffic. Primary objectives are efficient usage of frequency spectrum, added safety through increased reliability and reduced burden to pilot and controller, and adaptability to all classes of aircraft. AGACS provides compatibility with existing ground and airborne communication equipment, selective addressing of information, and a minimum number of frequency changes during flight. The system utilizes two-way time division data transfer over existing ground and air communication links to provide an automatic, mutual exchange of information. The airborne facilities display to the pilot the last significant Air/Ground and Ground/Air message quantities, while the controller may recall from central memory-storage equipment the last Air/Ground and Ground/Air message quantities for display. The AGACS program is still in the developmental stage. In August, 1959, RCA provided initial models of both airborne and ground equipments for the Bureau of Research and Development of the Federal Aviation Agency for extensive experimentation and flight tests.

RCA

Tmk(s) ®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N.J.

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He has brainstorms ...to order

He's one of a group of AMF scientists who develop solutions to the utterly original problems of modern defense and human penetration of space. He doesn't build *better* mousetraps. His business is completely new kinds of traps for mice that have never been caught.

Examples: A method of recovering potable water from human waste fluid, the major source of water in a sealed space vehicle... Methods of analyzing the effects of a nuclear blast on the earth's crust, how it changes the character of soil and rock, how its shock is propagated, what sort of building structure will withstand it... Platforms on which will be mounted primary standards calibration instruments for missile guidance systems. These platforms must be so vibration-free that natural earth movements must be compensated for. Platform vibrations are limited to millionths of an inch ...A method of predicting temperatures in missile nose cones upon re-entry.

Single Command Concept

These samples of creative ingenuity reflect the resourcefulness AMF brings to any assignment.

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more about the missile week

- **Edwards AFB, Calif.**—A **Boeing** *Minuteman* test vehicle shot skyward from an underground silo for the first time Sept. 15. The three-stage ICBM reached 200 feet above the ground before its flight was checked by a nylon cable attached in a noose to its nose. The first stage carried only enough solid propellant to launch the missile from the silo. The other two stages were dummies.

- **Washington**—Soviet Premier Khrushchev indicates it may be a long time before the Russians try to land a man on the moon. "We value human lives," he said at the National Press Club last week. He said Russia would consider shooting a man moonward "when the technical possibilities have been achieved. And that has not happened at this time."

- **Washington**—NASA Administrator Dr. T. Keith Glennan declared that Russia's successful moon shot would not cause any major change in the U.S. space effort.

- **Huntsville**—Dr. Wernher von Braun, director of development for the ABMA, sees Russia staying far ahead of the U.S. in space. "We have the brains, the resources, the capability, but we are hampered by continuous evaluations, justifications, re-justifications instead of progressing in our development in space projects." Added von Braun: "If Russia stops immediately we could catch them in one, two or three years."

- **Moscow**—Television observation of the moon and planets via satellites and rockets is next on the Soviet space program. Echoing Khrushchev's Washington statement, officials said that no manned flights would be attempted until the safe return of human passengers was assured.

- **Washington**—Wilfred J. McNeil, 58, resigned last week as Defense Department comptroller—effective Nov. 1. He will become president of the Grace Steamship Line.

- **Washington**—President Eisenhower signed the $1.4 billion military construction money bill. The bill—cut nearly $200 million below what the President requested—includes $550 million for construction of ICBM bases.

- **Cape Canaveral**—An Army *Jupiter* carrying frogs and 14 pregnant mice and other NASA experiments in its nose began to falter seconds after launching Sept. 15 and was destroyed. The IRBM developed engine trouble the day before—only a few hours before Premier Khrushchev arrived for his U.S. visit—and the downrange launching was understood to have been postponed for at least two weeks. Then the launching was suddenly put back on schedule for the next day.

- **Cape Canaveral**—The last missile of the much-troubled pioneer *Vanguard* series failed to ignite during a launching attempt in the early hours of Sept. 15. The *Vanguard* carried a 100-pound payload. Its launching was postponed indefinitely.

Shell-Casting Method to Cut Casting Time, Cost

LAVERNE, CALIF.—**Mercast Corp.** last week announced perfection of a new method of shell-casting of metal, which it said would allow faster casting and lower cost for many missiles, aircraft and electronic components.

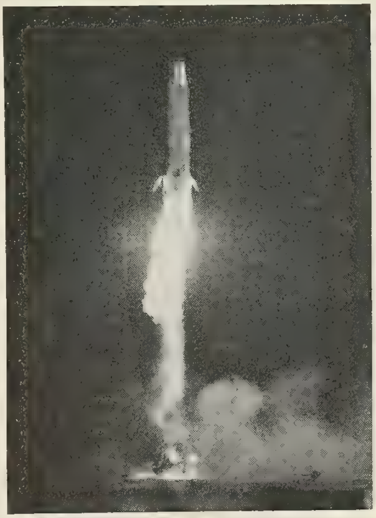
A company spokesman said the new process, called "Ceramercast," allows the casting of configurations too large and too complicated for the existing processes that make use of lost-wax molds and frozen mercury. It makes possible precision castings of components that now must be produced by machining.

Semiconductor Output Being Increased by RCA

Radio Corporation of America is building a 120,000-square-foot plant at Mountaintop, Pa., near Wilkes-Barre, to expand its production of mesa transistors and silicon semiconductors. Plans call for manufacturing to start in mid-1960 with the employment of "many hundreds" by the end of the year.

The company estimates the semiconductor industry will have sales totalling $350 million in 1959. By 1965 they will approach $650 million a year.

Melpar Inc., a subsidiary of **Westinghouse Air Brake Co.**, is constructing a $2.4 million facility at its Falls Church, Va., headquarters to step up its electronic output. The building will be finished a year from now . . . With some floor space idle at its Dallas Plant, **Temco Aircraft Corp.** is now offering "instant manufacturing" capabilities to other firms through a new Industrial Division . . . **The Martin Co.** has created a new electronics division at Denver headed by G. Howard Teeter. . . . A 6000-square-foot refractory metals fabrication plant being erected by **Sylvania Electric Products Inc.** at Towanda, Pa., is scheduled to be ready early next year . . .



FIRST OPERATIONAL *Atlas* **fired by SAC troops at Vandenberg AFB on Sept. 9 is shown at blast-off in an official Air Force photo. It landed near Wake Island, 4300 miles west.**

Atlantic Research Buys Jansky & Bailey from GC

For a "substantial" amount of cash and stock, **Atlantic Research Corp.**, Alexandria, Va., propellant manufacturer, has purchased the Washington, D.C., electronics and communications firm from **General Communication Co.**, Boston.

ARC also acquired in the transaction 16% of the outstanding GC stock with a 5-year option to acquire a total of 25%. Dr. Arch Scurlock, ARC president, also becomes a member of the GC board.

Red Moon Hit Shows Guidance Prowess

by Paul Means

WASHINGTON—The Soviet Union launched a moon rocket on Sept. 12—three days before Premier Khrushchev's visit to the U.S. (as predicted by M/R Aug. 17, page 9).

The rocket's achievement gave further testimony to the accuracy of Soviet space vehicle guidance, the ability of Soviet space boosters to lift heavy payloads, and the capability of Soviet rocket engines to achieve specific desired velocities.

Early computations indicate that *Lunik II* had an injection arc error of only 1.5 seconds and a deviation from planned cutoff velocity of less than plus or minus 25 feet per second.

By comparison, a *Vanguard* can have an injection arc error of 1.5 degrees and still go into orbit. An *Atlas* ICBM can have an injection arc error of 10 seconds and a velocity cutoff error of 50 feet per second and still be effective.

As Dr. Herbert F. York, DOD R&E chief remarked last week, it is an easier guidance problem to hit the moon than it is for an ICBM launched from New York to hit Moscow. But, accepting the Soviet statement that they aimed for the center of the moon, and comparing the probable error (approximately 500 miles) to an ICBM trajectory of 6000 miles, the ICBM would have to miss the center of its target by less than 1½ miles to do as well.

There are other factors—such as re-entry (the moon has little atmosphere) and the report that the Soviet rocket was said to have had fourth-stage guidance—which do not make the two situations comparable.

• **Strong evidence**—In contrast to *Lunik I*, there was no doubt this time that *Lunik II* was launched and that it traveled very close to the moon. Major tracking installations in the free world—including the mammoth radio telescope at Jodrell Bank, England, and the 85-ft. parabolic dish at Goldstone, Calif.—locked on to the rocket's transmitter and received strong, usable signals.

A U.S. scientist theorized that the Soviets could have designed a clock mechanism for the rocket's transmitters which would have turned off the signals at the time the Russians said the payload would hit the moon. An overwhelming number of rocket experts disagreed, pointing out that it would have almost been impossible to fake the Doppler shift or acceleration change in the signals that was noted by Jodrell Bank when the rocket came within the moon's gravitational field.

Final proof of the Soviet success will come when the signals recorded by Jodrell Bank are fed into a computer.

Also in dispute was a statement by Vice President Richard M. Nixon that the Russians had failed three times in the two weeks preceding Sept. 12 to launch a moon rocket. Though U.S. intelligence and radar stations may have picked up three rocket failures, astronomical conditions were not favorable for a moon shot during much of this period.

• **New fuel used?**—Judging from the Soviet description of its trajectory and payload, *Lunik II* apparently was a sister vehicle to the earlier Russian moon rocket. One Soviet scientist hinted, however, that the new rocket used a new fuel combination. The vehicle was probably launched at the Russian base northeast of the Aral Sea. (See M/R, Sept. 7, p. 21.)

The final stage and payload contained 780 pounds of scientific instruments, small rockets and a guidance system, and pennants bearing the Russian coat of arms.

The instruments included radiation experiments designed to reveal more information about the earth's charged particle belts, the earth's magnetic field, cosmic rays, micrometeorites, and about interplanetary gas.

The capsule was said to have carried a special radio circuit called a "moon altimeter" which, when switched on just before impact, was to supply information about changes in the rocket's altitude relative to the surface of the moon. Judging from the weak signals Jodrell Bank received before impact, it is doubtful that this instrument yielded information.

Like *Lunik I*, *Lunik II* released a sodium cloud at about 88,000 miles. The director of the Abastuman Observatory of the Georgian Academy of Sciences reported his team took 12 photographs of the cloud, one of which was released to the Western press.

Prof. Yugi Kalinin, Russian specialist on terrestrial magnetism, said that the rocket would also help verify that the liquid core of the earth is the source of its magnetism. The moon is known to have no liquid core, and if no signs of magnetism were recorded when the rocket approached the moon, the hyphothesis would have a stronger basis.

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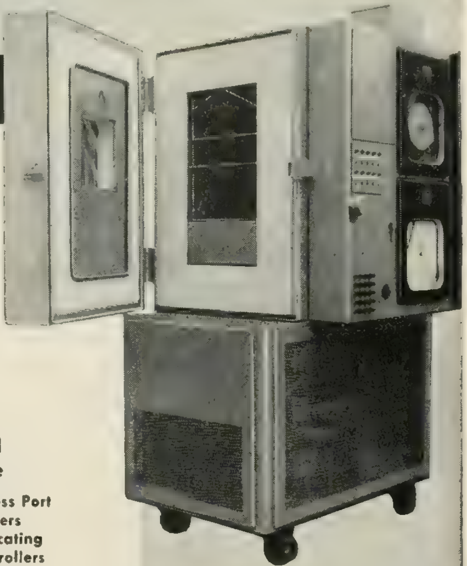

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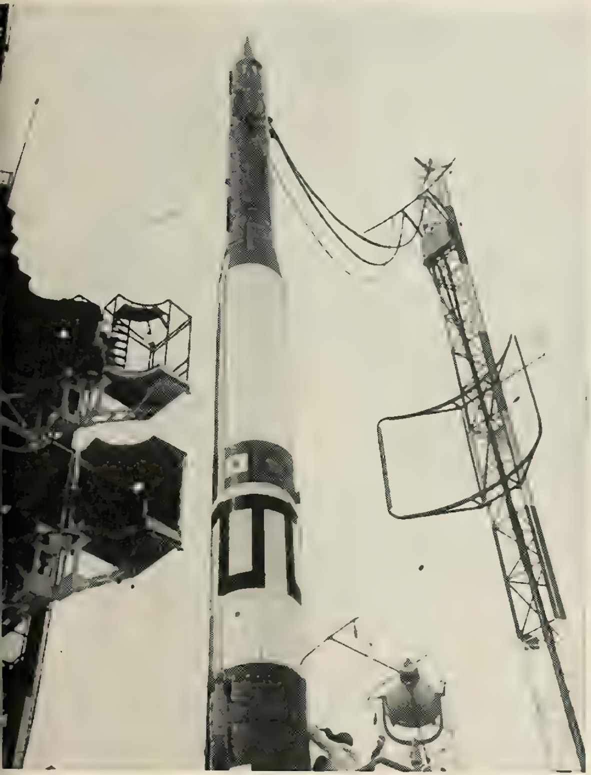
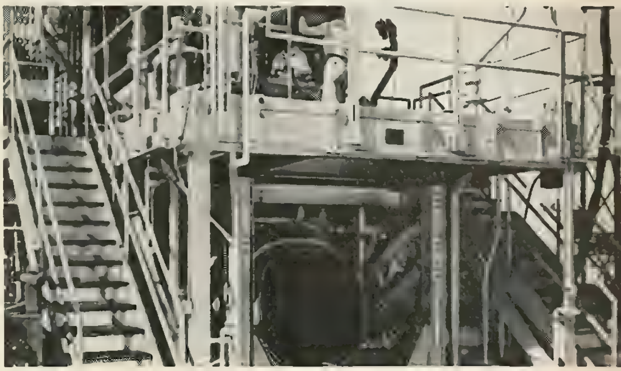


Vanguard rocket being readied for launching on March 17, 1958.



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west coast industry . . .

By FRANK G. McGUIRE

Considerable irritation is being expressed by newsmen over their handling during the recent operational *Atlas* shot at Vandenberg AFB. Following a statement at the AFA meeting in Florida that the launching was scheduled for September 9, USAF here declined to confirm or deny that the date was accurate, and would not permit reporters to cover the shot. Finally, one and a half hours before launch time, the press was notified in Los Angeles that it could cover the event. Driving time from LA to VAFB is three and a half hours. Celebrations planned by **Convair** and the Air Force were reluctantly cancelled, following orders from Assistant Defense Secrectary Murray Snyder that the shot be closed to the press. No reason was given for the orders.

Electronics Capital Corporation . . .

has made five appointments to its executive staff. The three-month-old company furnishes capital and management to electronics and allied firms capable of associating in special groups to bid on government contracts. Clarence A. Wetherill, senior technical officer, was formerly chief engineer at **Stromberg-Carlson;** Elliot Lewis, assistant to the president, organized and directed the PR department at **Ramo Wooldridge;** Harold M. Gruener, senior management services officer, previously was executive VP and general manager of **Intertectics Corp.;** Daniel I. Fellers, controller and financial planning officer, joined ECC from his post as assistant professor at San Diego State College; and Wilford D. Willis, assistant general counsel, was formerly contract administrator for the **Convair** 880 program.

Meletron Corporation has split . . .

into two separate corporations owned by the same stockholders, and retaining George A. Starbird as president of both. The **Meletron Corp.** becomes a sales and engineering firm, transferring all production activity to the newly-formed and wholly-owned subsidiary, **Pressure Switch Corp.** Richard L. Shelton, comptroller for three years, becomes vice president and manager of PSC. Sales for the year ending July 31 were $1,750,000.

Lockheed's hourly-paid employes . . .

have received a cost-of-living bonus amounting to 2¢ - 3¢ per hour, depending on job held. Maintenance electricians get the 2¢ raise, and all other hourly-paid employes receive the 3¢ raise.

No subcontracting worries in Russia . . .

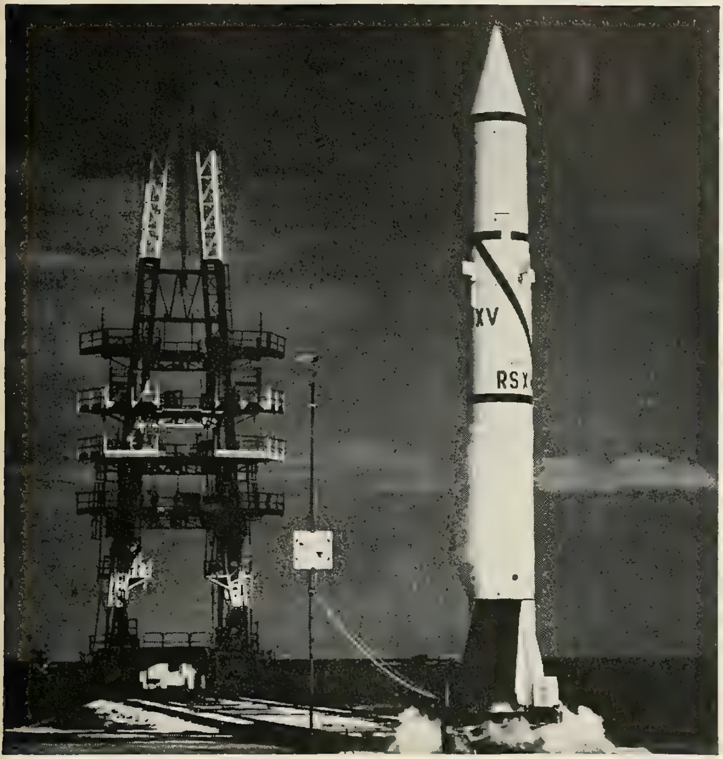
according to George P. Brubaker, president of **Brubaker Electronics** and VP of **Telecomputing Corp.** "Major plants in Russia are completely self-contained," he said, "and handle all the minor work that we would subcontract out. When something rolls off the line over there, it's ready to go to work." He predicted that the USSR will soon lead the United States in steel production, and possibly in oil production. "The United States is on an economic island," he stated, "and will soon face the question: 'How long can we trade with ourselves?' There might be benefits in trading with the USSR."

Houston Fearless Corp. reorganization . . .

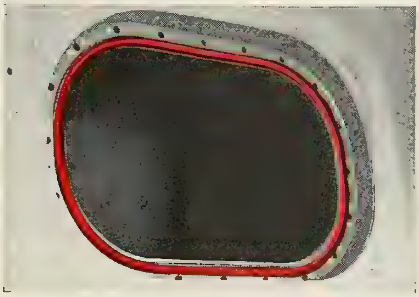
recently approved by the California Corporation Commission, has brought a powerful management group to the company. Noah Dietrich, former Howard Hughes financial associate, Emmett Steele, ex-**Litton Industries** military sales head, and Richard Woike, Eastern financier, are expected to take the company into much bigger things. The firm says it is now "up to our ankles in military electronics, and will soon be up to our necks." Barry Shillito, former **Hughes Aircraft** Sales Director, joined the 30-year-old company this month, and he will reportedly be followed by additional management talent. HF is paving the way for a number of acquisitions soon, in the areas of advanced military and industrial electronics, with emphasis on communications and guidance.

SILICONE NEWS from Dow Corning

Semper Flexibilis



Sealing the nose cone on the Army Redstone is an extrusion of Silastic. Silastic maintains a positive seal despite long periods of storage under load and adverse operating temperatures.



A similar application for Silastic, this time on the Army-developed Jupiter IRBM, another Chrysler-produced missile, is the seal on the angle-of-attack transducer compartment. Silastic was specified because it resists high temperatures encountered in re-entry.

SILASTIC SILICONE RUBBER seals missile sections; withstands -130 to 500 F

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Chrysler Missile Standard Bundle clamps on both Redstone and Jupiter missiles are fabricated of Silastic. Electrical properties of this material are excellent.

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$245,000—**Electro-Mechanical Research, Inc., Ascop Division**, Princeton, N.J., for four mobile self-propelled FM/FM telemetry trucks.

$200,000—**Telemeter Magnetics, Inc.**, Los Angeles, for a core memory.

$107,000—**Syracuse University**, for research in high-energy physics.

$44,490—**Purdue Research Foundation**, for studies pertaining to arc plasma.

$42,411—**Dunlap & Associates**, for research in connection with *Tartar* weapon system.

ARMY

$4,900,000—**Aerojet-General Corp.**, Azusa, Calif., for surveillance drone systems.

$3,900,000—**Kaiser Steel Corp.**, for tower for *Saturn* project.

$2,697,117—**North American Aviation, Inc., Rocketdyne Division**, Canoga Park, Calif., for research and development.

$2,000,000—**Raytheon Manufacturing Co.**, Waltham, Mass., for engineering services on the *Hawk* missile.

$1,893,432—**Blount Brothers Construction Co.**, Montgomery, Ala., for construction of *Bomarc* facilities at Langley AFB, Va.

$1,676,814—**Douglas Aircraft Co., Inc.**, Santa Monica, Calif., for maintenance and operation services for the *Nike-Hercules* anti-aircraft missile.

$1,641,714—**Bell Aircraft Corp.**, Buffalo, N.Y., for a visual surveillance system.

$1,634,762—**Purvis Construction Co.**, Yardley, Wash., for construction of a radar site at Sundance, Wyo.

$102,238—**Tung-Sol Electric, Inc.**, Newark, N.J., for electron tubes. (Two contracts.)

$97,908—**Radio Corp. of America**, for study and development of a calculating light modulator.

$68,064—**Radio Corp. of America, Electron Tube Division**, for electron tubes.

$31,501—**Western Electric Co.**, N.Y., for *Nike* spare parts and components.

AIR FORCE

$73,400,000—**Avco Corp.**, N.Y., for research and development on *Titan* nose cone.

$36,700,000—**Avco Corp.**, N.Y., for *Minuteman* nose cone.

$29,209,851—**General Electric, Missile and Space Division**, Philadelphia, for production of *Thor* IRBM nose cones.

$9,000,000—**Burroughs Corp.**, for thirty-six SAGE air defense units.

$5,200,000—**Sperry Gyroscope Co.**, for radar sets.

$5,000,000—**Martin Co.**, Orlando, Fla., for work on *White Lance* air-to-surface guided missile.

$4,500,000—**Radiation, Inc.**, Melbourne, Fla., for development of airborne telemetry system for *Minuteman.*

$1,059,300—**Dynamics Corporation of America**, for twenty portable radar antennae groups.

$500,000—**Electronic Specialty Co.**, Los Angeles, for electronic fusing timers for the *Genie* air-to-air missile. (Subcontract from **Douglas Aircraft Co., Inc.**)

$300,000—**Marquardt Aircraft Co.**, Ogden, Utah, for services in connection with the testing engines used on the *Bomarc* missile.

$182,000—**Boller & Chivens, Inc., Joseph Nunn & Associates**, S. Pasadena, for satellite tracking camera.

$150,000—**National Research Corp.**, Cambridge, Mass., for high-energy solid propellant missile fuels.

$95,550—**Raytheon Co.**, Waltham, Mass., for electron tubes.

$61,000—**Convair Division of General Dynamics Corp.**, for development of X-ray standards for determining the strength of steel castings.

$42,761—**Yale University**, for research on kinetics of Uninolecular and Halogen atom reactions.

$40,000—**Amperex Electron Co., Division of North American Phillips Co., Inc.**, for electron tubes.

$30,700—**University of Minnesota**, for continuation of research in gaseous electronics.

$27,202—**University of Wisconsin**, for research on Addition and Displacement Reactions with Unsaturated Hydrocarbons.

MISCELLANEOUS

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$2,000,000—**Advanced Technology Labs**, for nuclear power reactor research and development.

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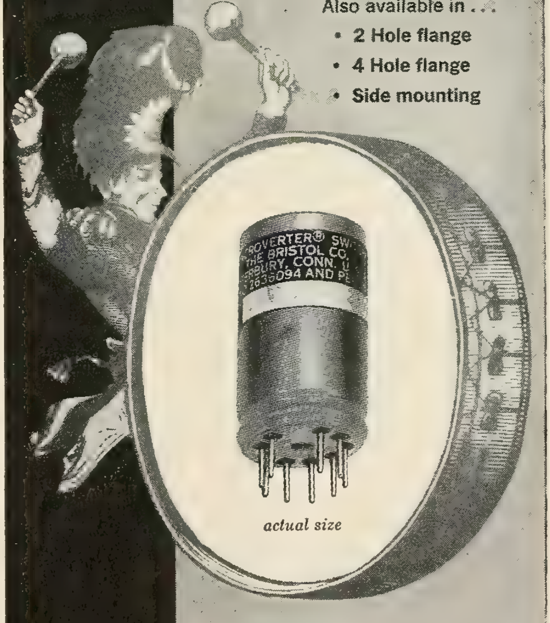

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ATICS

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moscow briefs

by Dr. Albert Parry

The model of Pioneer IV, seen by Professor Georgi I. Pokrovsky at the American exhibit in Sokolniki, impressed this outstanding Soviet rocket expert as "made quite well." Writing in *Sovetskaya Aviatsia* of his impressions, Dr. Pokrovsky states that since Americans "succeeded in maintaining radio communications with this construction at a distance of more than 600,000 kilometers," this U.S. satellite of the sun "doubtless represents an achievement of American instrument-making." But he criticizes the small size of *Pioneer IV*, "so small that it could serve as a desk ornament." He writes: "These dimensions apparently are not accidental. They are due to the weak force of American rockets which still are not able to hurl heavy enough machinery into outer space." He compares the lag in American rocket size and strength with the tremendous payloads of the Soviet *Sputniks* and *Lunik*.

Pokrovsky also comments on the model and photos of our *X-15* as studied by him at Sokolniki. He complains that the U.S. exhibit told him of the *X-15* "essentially less than is already known from the world's technical press." He notes that the *X-15* "has not as yet even once flown on its own rocket motor."

Professor Georgi I. Pokrovsky is not only a doctor of the technical sciences, but also a major general in the engineering-technical branch of the Soviet armed forces and, since 1947, on the faculty of the famous Zhukovsky Military Air Academy in Moscow. In technical literature he is known particularly for his book on *Guided Effect of Explosion*, written as early as 1942. Since 1957 he has written and published extensively on Soviet ICBM's. Professor Georgi I. Pokrovsky is not to be confused with Professor Alexis V. Pokrovsky, who is among the chief trainers and observers of dogs used in Soviet rocket shoots.

No Red missile base on Ruegen, says *Krasnaya Zvezda* as it reveals that East German Communist authorities recently took a group of West German newspapermen on a tour of that strategic Baltic Sea island, to prove to them that, despite reports in the Western press, not a single Soviet rocket installation existed anywhere on Ruegen. The tour took "nearly a day," the daily organ of the Soviet ministry of defense writes, but "instead of any rocket bases" there were on the island resting facilities for summerfolk and nothing else.

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GENERAL ELECTRIC

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The memory of the Russian who was among the first to work out equations of motion of bodies with variable mass, and thus originated some of the fundamentals of the rocket propulsion theory, is now being honored in the Soviet Union. The 100th anniversary of the birth of Ivan Meshchersky was marked in August in the Soviet press and from the Red lecture pulpit. "It Is to His Labors that *Sputnik* Owes Its Existence," proclaimed a headline in *Komsomolskaya Pravda* on the occasion of Meshchersky's centenary. A professor at the St. Petersburg (now Leningrad) Polytechnic Institute, Meshchersky worked out and published his equations in the period 1897-1904. By 1959 his *Collection of Problems in Theoretical Mechanics* has gone through more than 20 editions.

A new monument to another Russian rocket pioneer was recently unveiled at the North Caucasian spa town of Kislovodsk. This is a memorial to Friedrich A. Tsander, a Lett from Russia's Baltic shore, who in 1908 began his rocket studies and experiments at the early age of 21, six years before he was finally graduated as an engineer from the Riga Polytechnic Institute. He was an ardent disciple of Tsiolkovsky. After the Soviet revolution, Lenin himself talked to Tsander, encouraging him in his rocket work and space-ship dreams. Tsander was a founder of one of the first Russian rocket societies, GIRD (Russian initials for the Group to Study Rocket Propulsion). Its members under his guidance built one of the first Soviet liquid-fueled rockets. Tsander died in Kislovodsk in 1933 at 46 before he could see this rocket's launching (it was fired successfully on November 25 of that year). The monument unveiled in Kislovodsk last month is tipped by an exact reproduction of Tsander's rocket.

Tsander is also remembered for his proposals to use aluminum and magnesium as rocket fuel.

Latest Soviet rocket joke circulated by irreverent Russians in Moscow—Question: "Why was Nicholas Bulganin like a rocket?" Answer: 'Because he launched Khrushchev into orbit but burned up himself."

Digging for *Titan*

Details of Work on A Hardened Complex

VANDENBERG AFB, CALIF.—Mine "mucking" and burrowing techniques are being used by construction engineers to dig a hardened *Titan* ICBM complex here.

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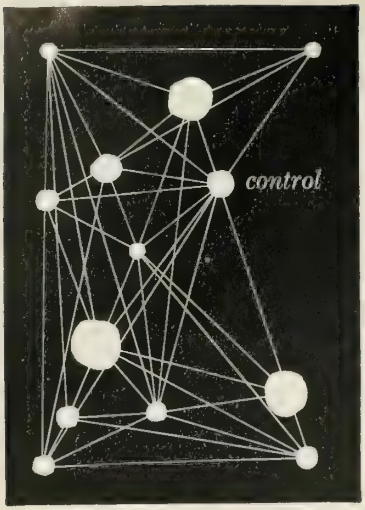

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through personnel access tunnels carrying piping, cabling, missile support connections and water between the missile silos, propellant terminal, equipment terminal, powerhouse and command control center. These units are all interconnected by tunnels ranging from 10 to 12 feet in diameter.

Usual clam-shell or drag-line methods could not be used in the excavation of the 43-foot diameter missile silos to a depth of 160 feet. Contractors instead employed a mucking machine with a half cubic yard toothed scoop, which bored the holes in the ground. Concentric ring pattern of dynamiting (with the center ignited first to prevent excess edge rock breakoff) was employed against shale.

The mucking machine dumped excavated material into a hopper which was hoisted to the surface by a 25-ton crane for disposal. With this system, **Daniel, Mann, Johnson and Mendenhall and Associates,** architectural and engineering group in charge of the project, reports excavation on a 'round-the-clock basis proceeded at the rate of 6 feet every 24 hours.

Silo shoring included 6 WF 25 beams, 6 x 6 x 10/10 electrical-welded wire mesh and gunite. DMJM says "the gunite proved to be more economical than steel sheeting and eliminated the necessity of grouting between the sheeting and the rock wall to fill the voids."

When tunnel openings were made later in the silo walls, instead of using only a jackhammer, the contractor drilled holes in the gunite at 12-inch centers and exploded one stick of dynamite every 30 inches. The silo walls are eight inches thick and 5000 psi in strength.

Silo walls were slip-formed in much the same manner as a grain silo, but with two big differences: 1) only one form was used for the inner wall face and, 2) a cylindrical, three-level slip form was suspended from steel rods attached to 20 cables equally spaced around the hile.

Ready-mixed concrete was poured at a rate of up to one-foot per hour at points where wall inserts did not slow down the operation. During pouring cycles pneumatic jacks pulled the slip form up the steel rods.

Surprisingly enough, the silo excavation required only up to seven men during preparation for blasting, and only two or three during the mucking cycle. Three men were on the crane and one on a dump truck.

Northwood Co., sub to general contractor **Matich-Sundt,** performed the excavation operation.

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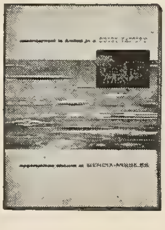

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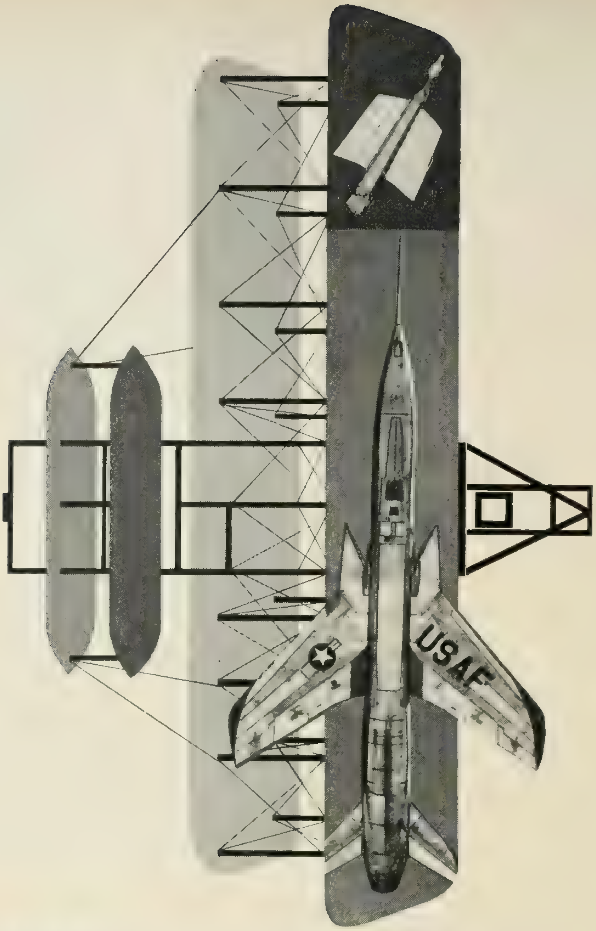

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editorial

Management—Major Support Problem

There are job openings these days—or soon will be—for several hundred young men in an absolutely new career field. The educational qualifications are exacting but not unusual. The experience has only been available in the past year or so. The techniques have to be learned mainly on the job.

The position? Missile Base Management Engineer.

The number one problem in the missile field today is that of managing the support systems. The scope of these systems runs from ten-penny nails to steel tubes 10 feet in diameter. It includes packaging and shipping, transportation, handling and automatic checkout, refrigerants, hydraulic and electric systems, storage and transfer of highly explosive fuels, valves, tubes, transistors—nuts and bolts. The missile support field utilizes and must have the talents of the architect engineer, the electronics engineer, chemical engineer, electro-mechanical engineer, mechanical engineer and construction engineer.

The duties of the Missile Management Engineer? To bring all of these component parts and skills together.

There is very little understanding today on the part of the public, Congress, the military and space agency—even industry itself—of the cost and complexity of the missile base management problem.

Consider the ICBM, either *Titan* or *Atlas*. Here is a missile built at a cost of approximately $2 million. A squadron of nine is moved to a base which cost $45 million to construct and another $45 million to equip. There the giant missile sits, pre-targeted, ready for its fuel, ready for its hydrogen warhead, linked by dozens of slender arteries to dozens of support systems which once—only once—may bring it to life. The time could be next month or next year, two years or five—or never. But if the call comes and at whatever time, every one of the thousands of parts in this vastly intricate system must work instantly and must work perfectly.

Only now and only barely are we beginning to realize that the missile base and the missile support equipment are simply extensions of the missile itself. A rifle bullet is made and fired from a gun, a shell from artillery, a rocket from an airplane. A manufacturer makes them according to specifications and there his responsibility ends.

With the big ballistic missile, the equivalent firing or launching mechanism must be designed concurrently with the missile. A company building a missile engine must know if that engine is going to be installed while the missile is vertical or horizontal—because while building the engine it also has to design and build a sling which can install it. And, just incidentally, how do you install a multi-megaton thrust engine in a missile approaching the size of the Washington Monument?

By the very nature of the situation, much of the ballistic missile support equipment has to be tested in the field. Much of it has been virtually built or rebuilt there. For example, we learn that in the first 30 days of construction of the *Atlas* base at Cheyenne, 70 change orders were passed down to the Corps of Engineers building the base. These orders simply reflected either changes in the missile itself or changes in a major piece of support equipment.

In another instance a company installing the communications system at a missile base so underestimated the difficulties of the job that they sent "desk" engineers to manage it. After some weeks of trying—including attempts to lay coaxial cables across dirt roads used by bulldozers—the company threw in its "red necks." Used to field conditions and to improvising, they got the job done.

No one in particular is at fault—just the circumstance that no one foresaw the magnitude and the complexity of the job which still has to be done. The military and industry are now learning the missile base facts of life, now beginning to understand that at an ICBM base the air conditioning, the power supply, the access tubes to checkout equipment—all of these and thousands of other parts and subsystems are just as important as the bird itself.

This missile base management job is an exercise in intricacy, a test of ingenuity, skill and vision, a bag of worms. And its solution is the most important problem facing industry and the military today if the ICBM is to take its place in the deterrent arsenal of the nation.

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ANSISTOR COMPUTERS. Two new -transistor computers, one to serve all businesses and the other to cope th the tremendous paperwork load of dustrial giants, were announced recently by the Radio Corporation of merica. The RCA 502 and RCA 504 e said to broaden the scope of the CA 501 electronic data processing sysm. Until now, the 501 system had ilized only the RCA-503, the mediumale computer. With this pair of addinal 'brains,' RCA believes the effiency of the RCA 501 system has been tended to meet virtually any data ocessing situation. According to RCA okesmen, the all-transistor RCA-501 stem using the 503 computer was deloped originally to bring full-scale ta processing to the medium-sized m.

cle No. 225 on Subscriber Service Card.

ENERATING SETS. The entire new line Diesel-Engine-driven Electric Generat- Sets, recently announced by D. W. nan & Sons Inc., is described and illusted in an attractive 2-color folder rently issued by the Minneapolis firm. ese heavy-duty Diesel Sets provide a pendable continuous source of eleccity for all types of rugged operans . . . oil fields, heavy construction es, mining camps, railroads and light nstruction jobs, too. And in emerncy power applications where low-vola- Diesel fuel is preferred over gasoline, ese new Onan Diesel electric plants ovide quick-starting auxiliary power hospitals, institutions, radio & TV stans, hatcheries, motels, microwave inllations and military requirements. ecifications and illustrations of these mpact, powerful Diesel sets, in sizes nging from 3,000 to 6,000 watts (airoled) and from 10,000 to 230,000 tts (water-cooled) are included in the page folder. Diesel-driven marine elec- generating plants are also described are a complete selection of accesries and controls.

cle No. 226 on Subscriber Service Card.

ECISION COUNTERS. A line of simfied design precision counters which said to completely eliminate transfer sks or shades and have no interrupted aring to complicate operation is ing offered by Chicago Dynamic Instries, Inc., Precision Products Divin. Series AD-1 counts hours, degrees, s, minutes, etc. and returns to zero, n repeats. Because these units do not unt in multiples of 10, they are ideal for applications where the counter must repeat from zero with continued rotation after a count other than 99,999,-9999, etc. such as 359 degrees, 6300 mils, 23 hours, 59 minutes, etc. Type 1400 degree counters read through 359.9° to zero and repeat with continued rotation. Type 1401 mil counters read through 6399 mils to zero and repeat with continued rotation. Both types are bi-directional and add with clockwise rotation of the input shaft. Both types have an operating temperature range —60°F. to +165°F and meet MIL-E-16400-B and applicable parts of MIL-STD-167.

Circle No. 227 on Subscriber Service Card.

COMBUSTION TERMINATION. By rapidly lowering the pressure in solid propellant gas generators such as those used in rockets, a valve by the Aero Supply Co. valve terminates combustion in the gas generator. The valve, No. 33-2258-000, is hydraulically operated and is designed so that it may easily be modified as to line sizes and configuration.

Circle No. 228 on Subscriber Service Card.

TRANSFORMER SERIES. An all-new 2 KVA series has been introduced to complete the range between the 1 KVA and 3 KVA Powerstat variable transformer types by the Superior Electric Co. Called the 126-226 Series, these compact, functionally designed variable transformers are available in open, enclosed, fused, cord-plug and enclosed terminal models; single, two-and three-gang types; manually-operated and in 5, 15, 30 and 60 second motor-driven assemblies. They feature zero waveform distortion, excellent regulation and high efficiency. The commutator surface is rhodium-plated for smooth operation and long life. Terminals accommodate push-on connectors, lug, wrap-around or soldered connections. Output voltage can be limited to line voltage or to 17 percent above line voltage. Single units in the 126 Series are for use on 120 volt, 1-phase lines and ganged units for 240 volt, 1-or 3-phase duty. Ratings are 12.5 amperes on constant-current loads and 18.0 amperes on constant-impedance loads. Single units in the 226 Series are for 240 volt, 1-phase lines and ganged units for 480 volt, 1-or 3-phase service. Ratings are 6.0 amperes on constant-current loads and 9.0 amperes on constant-impedance loads.

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MISSILES AND ROCKETS

SEPT. 21, 1959

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MISSILE LITERATURE

FILTER MATERIALS. A two-page, two-color, 8½ by 11 in. bulletin describing seven basic filter element materials and various series of filter assemblies and replacement elements is now available from the Bendix Filter Division, Bendix Aviation Corp. The bulletin illustrates each of the filter element materials with two photographs, including photomagnifications. The materials discussed provide particle size control from ½ to 250 microns in temperature ranges from minus 350F to plus 1500F. Nine different filter assembly and replacement element combinations are also illustrated with photographs.

Circle No. 200 on Subscriber Service Card.

EPOXY RESIN. Processes for insulating transformers to meet the grades of MIL-T-27A with scotchcast brand epoxy resin are outlined in a new eight-page booklet issued by the Minnesota Mining and Manufacturing Co. Sections of the booklet deal with background on MIL-T-27A, transformer design, resin handling and proven processes for applying epoxy resins. The methods outlines include: dip coating, molding potting metal encased units and encapsulating open type transformers. The booklet is intended as a guide to the construction of transformers to military specifications, their design and special techniques which have been successful in meeting such specifications.

Circle No. 201 on Subscriber Service Card.

RADIATION SOURCES. A 12-page brochure has been put out by Nuclear Systems Division of The Budd Co. detailing its capabilities to provide radiation sources for irradiation research, radiography and teletherapy. The publication illustrates and describes Nuclear Systems radioisotope encapsulation facilities—its hot cell has a 50,000 curie capacity—its training courses for new customers, and its lines of radiography, teletherapy and irradiation sources.

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GAS TURBINES. A 12 page booklet issued by General Electric describes the new J85, a compact, lightweight turbojet designed to power subsonic and supersonic missiles, drones, and small-to-medium size piloted aircraft. Included is information on engine design, performance, test progress and current applications on Northrop's T-38 "Talon" trainer and N-156F "Freedom Fighter," the McDonnell GAM-72 decoy missile and Northrop Q-4B Supersonic target drone.

Circle No. 203 on Subscriber Service Card.

DATA PRODUCTS. A quick-reference catalog on Benson-Lehner data products defines the term "record reader" and discusses the various types of record readers produced by the Corporation. The catalog discusses special purpose record readers which are used to convert information recorded in pictorial or graphic form into either digital or proportional analog resistance form. The catalog also describes various types of automatic plotting machines used for graphing business, military, and scientific data from a variety of inputs including punch-cards, punch-paper tape, magnetic tape, manual keyboard and the outputs of automatic data handling systems.

Circle No. 204 on Subscriber Service Card.

INPUT SCANNER. A new bulletin d
tailing specifications and features of
multiple point input scanner is now ava
able from the KIN TEL Division of Co
Electronics. The bulletin describes t
KIN TEL model 453M scanner, an
tremely flexible and versatile input d
vice designed for any application whe
a number of signals must be scanne
Up to 400 individual points can
scanned by the model 453M and wi
a 453S slave unit attached, 1000 poi
may be scanned. Channel numbers
displayed on a 3-digit readout in nu
erals 1⅛" high. Switching is acco
plished by electromechanical stepp
that advance each time the inp
reaches null balance. Complete inf
mation on operation, application
available accessories for the model 45
are included in the bulletin. Specifi
tions covering the scanner's controls, c
play and timing are listed in detail

Circle No. 205 on Subscriber Service Ca

PACKINGS. A revised catalog issu
by the Greene, Tweed & Co., prese
in detail what Palmetto self-lubricati
packings are and describes their adv
tages and applications on pump r
and shafts and valve stems. The
opens with a description of the four
ferent stranded forms of Palmetto s
lubricating packings and their constr
tion methods. The booklet's data inf
mation includes calculator tables
weights and lengths, and order instr
tions. Each one of the 29 Palmetto s
lubricating packing types is illustra
and described. Details include rec
mended service, uses, temperature lim
sizes, standard packagings and pri
One page is devoted to a compreh
sive applications chart which pinpoi
the correct type of packing for e
type of service. Molded Packings
Sheet Packings are also illustrated.

Circle No. 206 on Subscriber Service C

THERMOCOUPLES. A newly revis
fully illustrated Catalog, EN-S2, of
complete information about Leeds
Northrup's full line of thermocouples
thermocouple components and acces
ies, and available on request. The p
lication lists and describes standard
semblies in protecting tubes and w
for general applications; speciali
thermocouples and assemblies for lab
atory and industrial applications, and
extensive line of bare and insula
thermocouple wires, replacement
ments, ceramic insulators, metal
ceramic protecting tubes, wells, term
heads and extension leadwires. Rec
mendations are given on the choice
use of thermocouples and assemb
and on the limitations of protecting t
and well materials.

Circle No. 207 on Subscriber Service C

PRINT, PLOT SCALER. A new desc
tive bulletin covering the firms M
ADRS2-5 Print-and-Plot Scaler is
nounced by the Victoreen Instrum
Company. The bulletin, Form 302
outlines the features of the instrum
which is described as being desig
for accurate digital and analog rea
of spectrographic equipment. In a
tion to giving suggested applicati
the illustrated bulletin details speci
tion and performance data.

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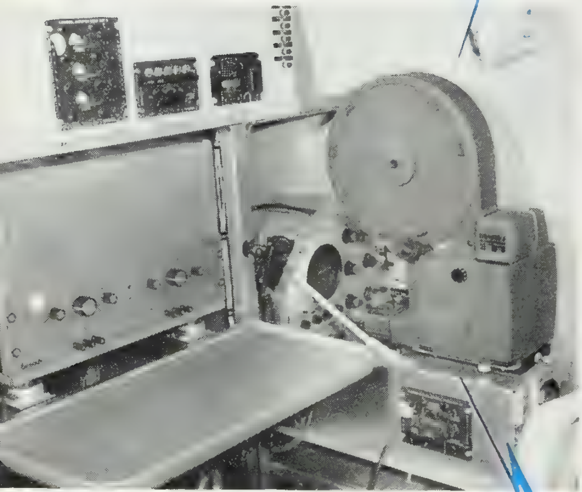
UNUSUAL CAREER OPPORTUNITIES FOR QUALIFIED SCIENTISTS AND ENGINEERS . . . WRITE AVCO TODAY.



There are seven Datasync Systems in each Convair FMIC Airplane, which provide multi-channel magnetic recording of Filmagnetic data in exact synchronism with "scientific shorthand" photographed from oscilloscopes, onto "Photo-Tape." *

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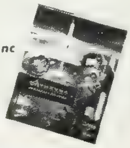
The basic design of this Aircraft is planned for down-range checking at all missile test and launching ranges. It may also be used for checking the functional and electronic environment of DEW Line installations and other defense system ground installations equipped with such components as SAGE "Texas Towers" and "P" Sites.

Datasync performance and reliability are guaranteed by Berndt-Bach's experience in manufacturing Electronic-Optical Recording Equipment since 1931.

* Trade Marks of Berndt-Bach, Inc.

The "Quick-Look" Datasync System capabilities of combined photo-recording and multi-track magnetic recording, are unexcelled. **Datasync** eliminates the time-consuming editing usually needed to synchronize the magnetic and photographic types of information.

* *Write for free, full-color illustrated Datasync "Catalog of Ideas"...*



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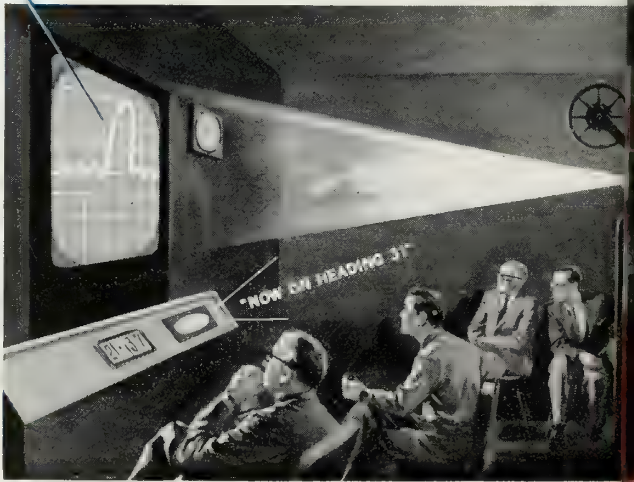

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LACK KNIGHT'S GAMMA

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

Breakthrough in Heat Treat 10
New Gyros Needed for Tomorrow 15
ARPA Wants $550 Million in '61 . . . 21

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INSTANTANEOUS RESPONSE

Grove Regulators...For over twenty years—from the first missile experiments in the Navy Experimental Statio at Annapolis to the launching pads at Cape Canaveral—setting the standards for the control of high pressure fluid ...the regulators which served as the critical control o World War II flame throwers and torpedoes...and mad missile development work possible...Grove High Pres sure Regulators...frequently imitated but never equaled

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GROVE VALVE and REGULATOR COMPANY

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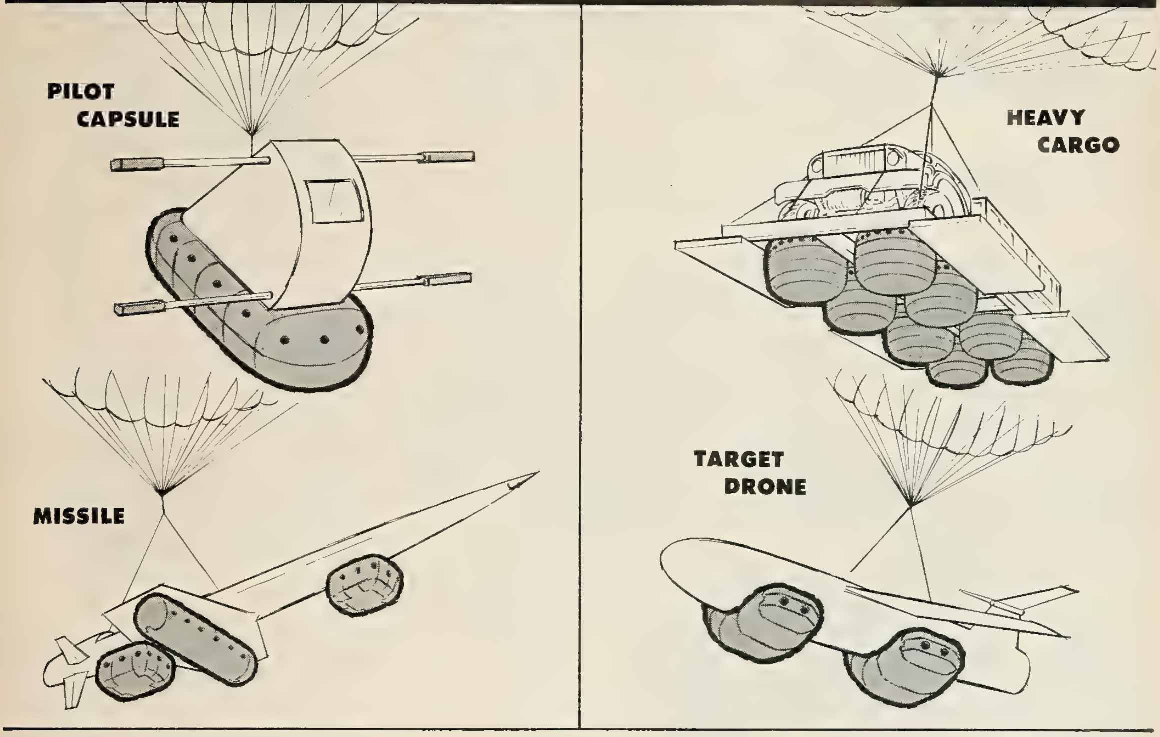
PNEUMATIC RECOVERY SYSTEMS / another product of Air Cruisers research



Solve New Missile and Capsule Recovery Problems

Air Cruisers has nearly a decade of experience in the development, testing and production of pneumatic recovery systems. Beginning with aerial cargo recovery, the company expanded its activities to include deceleration systems for various missile and target drone applications.

Other Air Cruisers system designs include recovery of missile nose cones and component parts, and pilot capsule recovery which enables the crew to land safely in the sealed capsule.

Air Cruisers' recovery systems consist of inflatable deceleration and/or flotation bags specially designed to meet all requirements:

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- Insure complete protection at normal drift and oscillation attitudes
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AIR CRUISERS DIVISION

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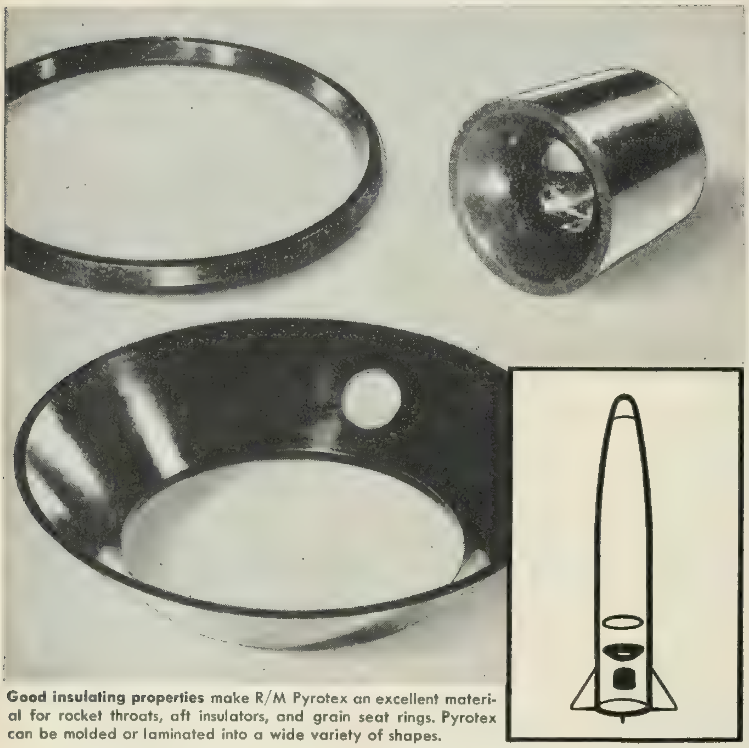
for low-cost, precision fabricated rocket parts—
both structural and aerodynamic



Good insulating properties make R/M Pyrotex an excellent material for rocket throats, aft insulators, and grain seat rings. Pyrotex can be molded or laminated into a wide variety of shapes.

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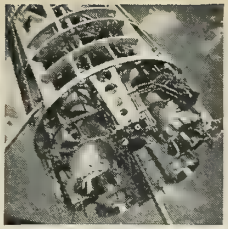
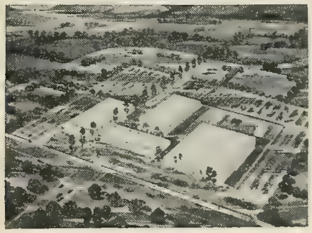


COVER: the Gamma liquid propellant multi-chambered rocket was developed by Bristol Siddeley Rocket Division to power Britain's *Black Knight* re-entry research vehicle.



ARCHITECT'S drawing of new Atomics International facility being built at Canoga Park is representative of the flow of missile/-space industry into San Fernando Valley. See p. 12.

PROTOTYPE of electrically-suspended gyroscope developed by Minneapolis-Honeywell. The guidance work of the future is going to demand big advances in gyros. A survey begins on p. 15.

PRE-LAUNCH check of *Vanguard* vehicle is supervised by Dr. John P. Hagen (at right), who directed the now-completed project for Navy and NASA. A review of the program starts on p. 35.

missiles and rockets .

MAGAZINE OF WORLD ASTRONAUTICS

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When the First Man Flies into Space... his Electronic Equipment will be Protected by ROBINSON!

CONTROLLED ENVIRONMENTS – PASSPORT TO SPACE

Soon, the X-15 rocket powered research vehicle, built by North American Aviation, Inc., will carry the first man into space. During this historic flight, many of the instruments installed in the X-15 will be protected against vibration and shock by Robinson mounting systems.

Robinson Model K710-14, all-metal mount, will protect 26 pressure transmitters connected with the rocket engine chamber, hydraulic fluid system, and the liquid oxygen, helium and ammonia supplies. Other Robinson mountings have been specified for the radio equipment and several other applications.

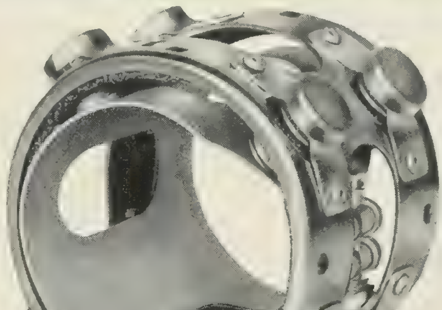
RADIAL MOUNTING SYSTEMS—
THE ULTIMATE IN CENTER-OF-GRAVITY SUSPENSION

Model K710-14 combines Robinson's MET-L-FLEX stainless steel resilient elements with an exclusive radial cushion, center-of-gravity design. The multi-directional isolation which results assures complete protection in the high intensity environments created by initial propulsion blast and re-entry.

During extensive development testing on the X-15 program, it was determined that vital instruments must be protected against vibration and shock to insure the calibration and accuracy required. ***Installation of Robinson mounting systems on the X-15 meets this requirement.***

INDUSTRYWIDE ACCEPTANCE

Twenty-three years of experience, plus unsurpassed creativity, make Robinson the choice of leading airframe manufacturers and weapon systems managers. These companies know that their equipment performs better and lasts longer when protected by mounting systems which have been engineered for reliability—by Robinson.



MODEL K710-14

ROBINSON *Technical Products Inc*
TETERBORO, N. J.

Formerly ROBINSON AVIATION INC. • West Coast Engineering Office: Santa Monica, Calif.

Washington Countdown

IN THE PENTAGON

A potentially hot study . . .
of the nation's missile range operations is being made by a special Defense Department committee. Particular attention is being paid to possible overlapping of facilities. The committee—headed by Detroit Businessman W. L. Cissler—is scheduled to come up with a report by mid-November.

• • •

An Air Force-Navy wrangle . . .
over the Pacific Missile Range is one of the thornier problems the committee is certain to investigate. The Air Force wants to continue R&D satellite launchings from Vandenberg AFB next year after PMR goes into operation at Point Arguello. The Navy says this would mean halting operations at nearby Arguello every time a polar orbit launching takes place at Vandenberg.

• • •

Some new codes names . . .
for ARPA projects to pin in your hat:

. . . *Shepherd,* the Army-Navy satellite detection fence that stretches across the southern part of the United States.

. . . *Steer,* a polar-orbiting instantaneous repeater communications satellite.

. . . *Decree,* a 24-hour instantaneous repeater satellite.

• • •

Killing the F-108 fighter . . .
by the Air Force left the United States with no long-range defense against enemy bombers packing air-to-surface missiles. The Mach 3 **North American** interceptor was a victim of the budget squeeze. **Hughes Aircraft** will continue work on the *GAR-9* at a reduced level.

• • •

The Army's *Pershing* . . .
will soar about 150 miles above the earth during its surface-to-surface flights. The solid **Martin** missile—replacement for *Redstone*—will have a 700-mile range.

• • •

The Navy's *Polaris* . . .
is undergoing a new test series at Cape Canaveral. The latest test vehicles have a 900-mile range—only 300 miles short of the range operational models are scheduled to have by the end of next year.

• • •

The Air Force's 609A . . .
a modified version of the **Chance Vought** *Scout* being developed for NASA, will be used for testing Air Force equipment. Unlike the *Scout,* 609A will not be used for launching orbiting space vehicles.

ON CAPITOL HILL

Heavy favorable reaction . . .
is reported by the House Space Committee in connection with its recent report on chemical-biological-radiological warfare. The report discloses some of the Army's latest work in the field. It also points out how new chemical gases and biological agents could be delivered in air-breathing and ballistic missiles.

• • •

Heavy heartfelt slugging . . .
is expected to result next year from Sen. John Sherman Cooper's bill proposing creation of a Defense Department director of procurement. Backers of greater unification of the services may use the bill as a rallying point. The military services will fight it down the line.

AT NASA

Space officials are worrying . . .
about reports of off-the-cuff remarks by Air Force officials that they plan to try for speed and altitude records with the *X-15* when they get it. The NASA officials feel the rocket plane won't be ready for such attempts.

• • •

Scotty Crossfield may quit . . .
North American at least temporarily to join NASA so that he can be a member of the *X-15* pilot pool. Other members of the pool are Air Force pilots Maj. Robert M. White and Capt. Robert A. Rushworth, and Navy pilot Lt. Comdr. Forrest S. Peterson.

AROUND TOWN

The Soviet man-in-space program . . .
may be suffering more difficulties than some have thought. A top Russian astronautics expert said recently when asked why Russia hasn't put a man in space: "Our rockets are not reliable enough yet."

• • •

Some of the reports . . .
being passed as "the latest" in the nation's capital:

. . . The Russians have a second *Lunik* booster ready for launching and may let it fly by the end of the year.

. . . The Canadians are seeking a greater role in joint defense planning.

. . . Politics appears to be slowing down the installations of U.S. IRBM's in Italy.

Industry Countdown

MANUFACTURING

Look for keen competition . . .
among the great variety of vehicles as the Army starts to choose those that will carry tactical missiles. The object is to find a vehicle system that is unrestricted by terrain, has efficient fuel consumption, and can provide rapid—but gentle—transit under a complete range of combat conditions.

• • •

New glass-plastic mix . . .
developed by **Armour Research Foundation** should have good missile application. It utilizes glass flakes in a resin-bonded laminate and has a fluxural strength of some 40,000 psi and a flexural modulus of 6-million psi. Tensile strength matches monofilament-wound structures but apparently with much greater rigidity.

• • •

Still another plastic . . .
is the TRC-X glass fiber phenolic laminate manufactured by **Riverside Plastics Corp.,** Hicksville, N.Y. The manufacturer claims it retains strength, dimensions and dielectric properties at temperatures in excess of 1000°F for minutes, which should give it real value in printed circuits and structures.

• • •

Alloy steels in 500,000 psi . . .
range have been developed by **Ford Motor Company's** Engineering division. In a process Ford calls "ausforming," austenitic steel is heated to 700°-to-1000°F, worked mechanically, quenched and tempered to a martinsitic steel at 500°F. Ford sees an obvious use in missile booster cases.

• • •

Materials center . . .
AF is proposing for Wright field may run into a snag with DOD Research and Engineering. The Pentagon wants all services to work on materials research.

• • •

AF has started a new campaign . . .
to assure larger participation of small business in defense production. Manufacturers will be required to file monthly reports of small and large business participation by weapon system.

PROPULSION

Plastic third stage . . .
may be chosen for *Minuteman.* Successful firing of a *Vanguard* with glass-filament reinforced plastic third stage developed by **Hercules Powder Co.** gives a lift to Hercules' chances of winning the third-stage *Minuteman* contest with **Aerojet.** Hercules plans the same kind of plastic case, loaded with double-base propellant, for *Minuteman.* AF has cancelled a contract with Aerojet for development of the back-up first stage. **Thiokol** work has progressed to a point where the need for a back-up stage no longer exists, AF says.

ASTRIONICS

Thermoelectric device . . .
with 50 times the capacity of any such device ever previously built has been developed for Navy by **Westinghouse Electric Corp.** It is, all at once, an air conditioner, space heater and refrigerator-freezer—designed for either submarine or space flight use.

• • •

Hottest range . . .
competition now in bidding stage is for a $30-million electronic environmental test facility at Army's Fort Huachuaca, Ariz. More than 60 companies in about 14 teams have submitted proposals. Cost bids are due Nov. 3. Contract will be awarded after Jan. 1.

WE HEAR THAT—

Lockheed MSD is transferring . . .
all major functions of its three advanced satellite programs into its newly activated $8-million Satellite Production building. Some 2500 persons are involved in the transfer to the 346,000-square foot building . . . **Smith Electronics, Inc.** of Cleveland has been awarded a theoretical study contract for a missile and satellite interferometer tracking system at Eglin AFB . . . **Artloom Industries, Inc.** has acquired **Eastern Precision Resistor Corp.,** an electronics manufacturing company with three plants in Brooklyn . . . **U.S. Transistor Corp.** has moved into a new plant in the Syosset Industrial Park, Long Island . . . **Marquardt** will construct a $1.25-million engineering and administration building for its Power Systems Group in West Van Nuys. The company also has established a Nuclear Systems Division . . . **Sylvania Electric Products Inc.** will purchase 50% of capital stock of **Fabbrica Italiana Valvole Radio Elettriche S. P. A.,** Italy's leading manufacturer of transmitting and receiving tubes . . . **Tapco Group** of **Thompson Ramo Wooldridge Inc.** will have a $2-million plant in Anaheim, Calif. . . . **Packard Bell** broke ground Sept. 15 for a new facility in Newbury Park in Ventura County, Calif.

• **Groton, Conn.**—The nation's second *Polaris*-firing nuclear submarine—the Patrick Henry—was launched at **Electric Boat Co.** here on Sept. 22. In the 38th flight test of *Polaris* at Cape Canaveral the day before, the solid-fuel missile traveled about 900 miles.

• **Cape Canaveral**—Another operational *Thor* was fired Sept. 22 in an accuracy test. No attempt was made to recover the nose cone.

• **Washington**—DOD said the **Callery Chemical** plant at Muskogee, Okla., will be kept in "standby" status at least until next June 30. The $35.5-million Navy boron plant will not go into production.

• **Torrance, Calif.—Linde Co.,** Division of **Union Carbide Corp.,** broke ground Sept. 15 for a multimillion-dollar liquid hydrogen plant that will provide up to 3.3-million pounds of liquid hydrogen annually to NASA. Completion of the facility on a five-acre tract is set for May.

• **Stamford, Conn.—Norden** division of **United Aircraft Corp.** has acquired an 80-acre tract in Norwalk, Conn., and soon will begin construction of a multimillion-dollar engineering-research and manufacturing facility.

• **Los Angeles**—University of California has been awarded an Air Force Office of Scientific Research Contract for basic research in adaptive control systems theory.

• **London—Rolls-Royce** has started test firings with the **Rocketdyne**-type engine to be used in *Blue Streak*. Tests are taking place at the Ministry of Supply's facility at Spadeadam in Northern England. First launching is scheduled for the Woomera range in 1960.

• **Azusa, Calif.**—Army has awarded **Aerojet-General Corp.** a contract for a feasibility study of a small rocket lift device to power combat troops on special missions. A seven months' study is expected to culminate in a recommended practical rocket system design.

• **Everett, Mass.—Avco Research Laboratory** will use newly designed laboratory models of a gas accelerator and a shock tube to investigate magneto-fluid-dynamic forces and other phenomena with respect to problems of propulsion in cislunar space for the Air Force Office of Scientific Research. The project will be directed by Dr. Arthur Kantrowitz and will cost about $585,000 for the first year.

Air Force Gets Bulk of ARPA Space Projects

WASHINGTON—The Air Force has all but won its long fight to become the one and only U.S. space force. Meantime, the Army received another strong shove toward the door.

This is the unavoidable conclusion resulting from the first, much sought distribution of ARPA space projects. (See page 21, this issue). However, there are several possible clinkers in what some defense officials thought was a smooth solution to their space problems.

The Defense Department announced Sept. 23 that the Air Force will eventually be given responsibility for all space transportation and military space boosters including the Army's 1.5-million-pound-thrust *Saturn*.

At the same time, the Department announced that four ARPA space propects had reached a stage of R&D where they could be turned over during the next year to the military services for final development. The four:

• *Midas,* the ballistic missile early warning satellite. It goes to the Air Force.

• *Samos,* the reconnaissance satellite formerly known as *Sentry*. It also goes to the Air Force.

• *Transit,* the navigation satellite unsuccessfully launched for the first time earlier this month. It goes to the Navy.

• *Notus,* code name for a family of communications satellites including *Courier, Decree* and *Steer*. They go to the Army.

The ARPA budget for FY 1960 includes $170 million for all four projects.

Defense Department R&E Director Herbert York said assignment of the projects to the services for final development and operational use was made by the Joint Chiefs of Staff, the Secretary of Defense and other top Pentagon officials.

The move ended months of squabbling over which service would get which project. In each case, projects were assigned to the service which had been developing them under ARPA's overall direction.

ARPA Director Roy Johnson and York stressed that the transfers were the first in a series that would result in eventual transfer to the services of all ARPA space projects, as they reached the proper stage.

However, they stressed that ARPA would continue to receive new advanced projects taking the place of old ones. Informed sources made clear that these would be both in space and other fields.

Underlying the announcements were several significant trends:

• The clear indication that although Redstone Arsenal space experts would continue to develop *Saturn,* the project probably would not be run by the Army (M/R, Aug. 31).

• The clear possibility of future interservice conflicts over the providing of Air Force boosters for Army and Navy space projects.

• The indication that the interservice fight over the rest of ARPA's present and future space projects is far from over. For example, assignment of Project *Shepherd,* the ARPA satellite detection fence developed by the Army and Navy, is overdue. However, no assignment was made.

Another significant turn was the shifting of all communications satellites to the Army, which for some time has sought control of all military communications systems. This assignment appears to give the Army a hefty push toward that goal.

An M/R Exclusive:

Breakthrough in Heat Treating Promises Huge Gains in Strength

Bassett process increases ultimate tensile strengths 10% to 60% with dividends in ductility—company confident of million psi in 18 months

by Frank G. McGuire

GARDENA, CALIF.—A breakthrough in the process of heat treating has boosted ultimate tensile strengths of metals by 10 to 60%, with proportionate increases in yield strength, coupled with gains in ductility, fatigue strength and impact strength.

The process, developed with $1 million of private funds in a 2½-year program by **Research Development Corp. of America,** is termed Thermomagnadynamics.

Approximately 50 observers from the aircraft/missile industry were on hand at a demonstration of the new process, and saw results of tests conducted on the spot. Visibly impressed, some termed the results "fantastic." RDCA is presently seeking ways to prove its process on production items, rather than solely on R&D coupon test results.

The process, discovered by William I. Bassett III, rearranges the metallic grain into an isotropic granular structure during heat treat and after fabrication. Photographs showing a 200X magnification indicate great consistency and uniformity in the resulting grain. Notch sensitivity is minimized in the process.

• **Potential realized**—Bassett points out that his process does not give additional strength to metals, but discovers the greater potential strength of metals and alloys. RDCA, of which Bassett is president, is now averaging 30,000 to 40,000 psi increases in tensile properties of metals, with equal to, or better than, elongation and reduction-of-area factors. RDCA hopes to achieve ½ million psi by 1960.

Another characteristic is that tested metal of any Rockwell hardness up to Rc 62 can be bent within its own radius at least 100 degrees without fracture. Commercial, as well as lab results, have been achieved on Martensite alloy steels, Martensite stainless steels, Alpha-beta titanium alloys, precipitation-hardening steels, and stainless steel alloys; other samples will be checked out in commercial jobs.

Jack Taub, executive V.P. of RDCA, is confident that the Bassett process will produce metal with ultimate tensile strengths of one million psi within eighteen months. He feels that this will be done by a combination of the heat treat process and the use of new alloys now being developed by the firm for utmost utilization of the process. He expects sales to be $1 million in the first year, and approach $10 million in the second year.

The company is not presently seeking government funds, but is awaiting finalization of patent proceedings so the process can be licensed for use by industry. RDCA is planning to construct a new, larger production facility in Torrance, which will include a larger furnace than their present equipment, capable of handling specimens 10 x 10 x 17 inches. A privately-owned corporation, RDCA presently occupies a 3000-square-foot plant and employs fifteen people.

Gerald W. Middy, vice president of sales for the company, points out that, although present results are R&D, they are based on thousands of tests and have proven extremely consistent. He said RDCA is interested in production steels, especially high-temperature steels, for applications.

It is estimated that four or five hours total process time has been average in R&D work, and that about the same time would be needed in production. Eventually, furnace time is expected to be less than one-half hour, with cost, using present equipment, about $200 per half-hour. A special furnace is now in use at RDCA, although the company points out that the process is not one of heat-treat alone.

• **Serendipity**—The company's first indication that it had achieved a significant improvement occurred during a routine introduction of changes in

*Results Obtained Through Use of Bassett Thermomagnadynamics Process on Metals**

Alloy	Ultimate Tensile Strength (PSI)	Elongation	Reduction of Area
4130	280,000 to 300,000	11%	30-40%
4340	335,000	11%	28%
6150 (.53% carbon)	375,000	9%	25%
6152 (.49% carbon)	361,000	9%	27%
Vascojet 1000	325,000	13.3%	37.5%
422M (12MoV) Stainless Steel	305,000	8%	20.8%
431 Stainless Steel	270,000	10%	32%
Thermold J (Unimac #2)	354,000	7%	22%
A286	174,000	25%	55%
Venango Special	418,000	8%	21%

*Results verified by independent testing lab, Metals Control Laboratory, 2735 E. Slauson Blvd., Los Angeles, Calif.

some normal processing methods, after which it was discovered that a smaller, more homogenous grain structure had been achieved. Almost 700 tests were thereafter conducted, and the results correlated. The best methods were then chosen from this data, commensurate with tensile results, yield strength, elongation, reduction of area, and a 90° minimum bend test.

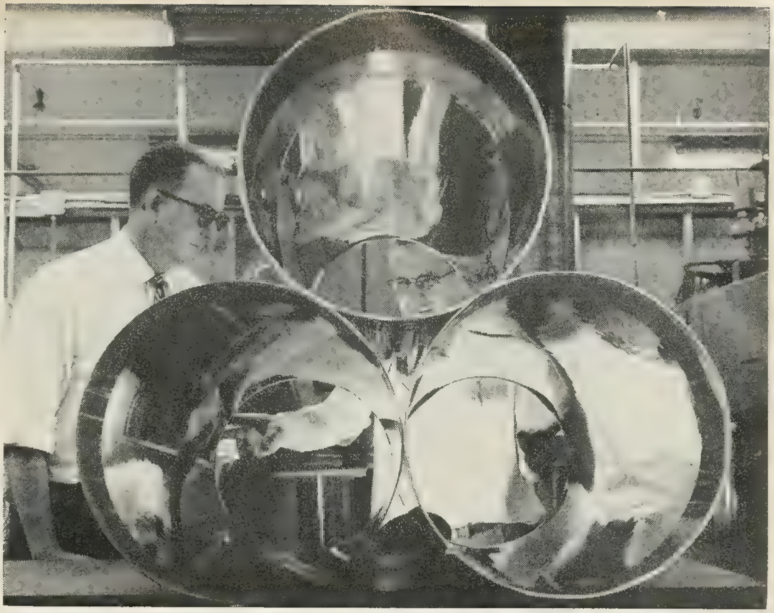
Bassett proceeded on the grounds that iron and other element metals are much stronger in the form of perfect crystals, and that this strength arises from the way in which atoms are uniformly distributed throughout the crystal, leaving no weak links. When crystallographic studies reveal that their iso-polar process influences the formation of an ultrafine and uniform grain, a tential stress applied in testing their parts with an equal elastic response occurring, the load is apparently evenly distributed. Additionally, they are free of heterogenous-sized grains, which serve as stress concentrations.

A good deal of the work thus far conducted by RDCA has been restricted by limited facilities, but large enough pieces have been processed to show that results do not vary with the size of the workpiece. The company's furnace has a guaranteed control of ±5°, an excellent dew-point control system (molecular sieve, gas cooled to -100°F.), and all parts are heated in an atmosphere which prevents the surface from oxidizing or reducing.

• **Help with titanium**—Fatigue life in type 431 stainless steel is around 14.6%, says RDCA, while the Bassett process consistently achieves a 50.8% fatigue life. Size effect is eliminated, enabling large sections to harden. Because of the excellent dispersion of carbides in the process, oxidation is slowed and there is more general resistance to all types of corrosion. The notch sensitivity of many alloys, titanium and stainless steel in particular, is greatly improved.

Also noteworthy is the Bassett process' effect on the glamor metal, titanium. Heat treatment of this metal is difficult, and reproducibility is often unattained. It is frequently impossible to meet strength requirements, or if these requirements are met, ductility suffers. The RDCA process provides 240,000 psi with an elongation of 11.5%, and guarantees reproducibility. RDCA says machinability doubles.

More common metals show similar results: 280,000 psi steels such as 4340 are now 317,000 psi with the same good usable properties: Chrome die steels are now over 325,000 psi with about 13.3% elongation and 37.4% reduction of area, compared with former levels of 280,000 psi, 7% elongation and 25% reduction in area.



ENGINEERS examine gleaming rocket test chambers fabricated by using unique strip winding and spot welding techniques developed by Ryan for use in *Polaris* program.

Ryan Gets Contract for *Polaris* Rocket Chambers

SAN DIEGO—**Ryan Aeronautical Company** has been awarded a contract to fabricate full-size chambers for the solid-rocket propellant of the Navy's submarine-launched *Polaris* missile.

The order from the Navy Bureau of Ordnance, announced by company president T. Claude Ryan, disclosed that the firm has been developing a unique welded "strip-winding" technique while performing research on an earlier phase of this project, in which many sub-scale model chambers were built in recent months.

Paper-thin steel alloys of great strength were used, a company spokesman reported, and tests simulated the enormous internal pressures encountered in the *Polaris* rocket motor. The cylinders reportedly showed they could withstand stress up to 305,000 psi static tension ultimate stress—far beyond that ordinarily achieved in industrial use of solid wall cylinders.

In the strip-winding method, several extremely thin sheets of steel are wound around a mandrel, tackwelded, and then spotwelded to create the wall thickness desired. A major problem overcome in the first phase of the *Polaris* rocket chamber research is reduction of stress concentration around the spot-weld through improved spot-welding techniques.

In addition to the steel alloy work, Ryan has been authorized to build at least one sub-scale model chamber of titanium, a metal with which the company has had considerable experience.

Ryan said the *Polaris* rocket engine chamber contract will extend his firm's work on this project to almost the end of this year, and may lead to production orders not only for *Polaris* but also for other advanced missiles.

Republic Designs New Missile Case for Solids

MINEOLA, N.Y.—A major technological advance in the manufacture of solid fuel rocket motor cases has been claimed by **Republic Aviation Corporation.**

The company reported that a fabricated missile engine casing made of low-alloy steel had successfully withstood pressures of more than 250,000 pounds psi, which represents tensile yield strength some 30% greater than that of similar-size operational casings made by conventional methods.

Second of A Series . . .

The Move into San Fernando Valley

R&D firms and electronics makers move into burgeoning industrial parks and campus-like centers; basic airframe industry follows slower pace

Gonna Make the San Fernando Valley My Home . . .

Popular Song

LOS ANGELES—Already defined as "a great city of merging satellites," the Los Angeles area might also be described as a huge region of merging industrial parks and campus-like research centers. Eventually, the Southern California complex of communities and their supporting industries is expected to fuse into one 200-mile-long city extending from San Diego in the south to Santa Barbara in the north.

The fabled San Fernando Valley, north of the heart of LA, is a natural "void" like the Orange County area to the south (surveyed in M/R, Sept. 7) and, in common with that county, is receiving a flow of much of the cramped industry from more crowded areas. Large companies such as **Thompson Ramo Wooldridge, Lockheed, Litton, Atomics International, Marquardt,** and many others are building in the valley—mostly with pleasantly-designed groups of modern buildings.

All is not expansion, of course, even in the electronics segments of the missile business. And this apparently applies even more in the airframe business. A spokesman for Aerospace Industries Association told M/R that the trend toward facilities expansion is not universal by any means. "I don't think any of our people are expanding," he said. "I think the reverse is actually true."

Douglas Aircraft Co., for instance, counts the wind tunnel development at its Aerophysics lab as its most significant expansion in the next year. Much of Douglas' future expansion depends on the fate of *Nike-Zeus*. The wind tunnel under construction at El Segundo is a three or four year program being handled in stages.

Similarly, **North American Aviation** is not contemplating any major moves in the near future, but is awaiting future developments. It recently completed a wind tunnel installation and is now building supporting facilities around it.

ONE OF the valley's new facilities now under construction is this group of labs for Thompson Ramo Wooldridge, at Canoga Park, designed by Albert C. Martin & Assoc.

The trend at NAA appears, then, to be a gradual but continuing movement away from putting all its eggs in the airframe basket. Electronics **(Autonetics Division),** rocket engines **(Rocketdyne Division),** nuclear energy (Atomics International), and other diversification has been underway for several years and is expected to continue.

In an industry where panic buttons are at a premium whenever a large contract is cancelled (*Navaho* is a perfect example), the lack of enthusiasm for undertaking multimillion-dollar construction programs is understandable. The aircraft companies, unlike electronics firms, are large enough already to handle any work they get . . . or if not, they team up with another company. It's cheaper than construction—and faster. The exception is research facilities.

• **Electronics must build**—Electronics is not in this position of being already big enough, nor is it so easy to establish teamwork in a technical and highly competitive small-item industry where proprietary information is so sensitive. This also applies to the electronics and research divisions of aircraft and missile companies, which are setting up new quarters just as quickly as pure electronics firms.

The electronics industry, one of the fastest-growing, has 461 plants in the Los Angeles area, employing 84,000 persons and doing an annual business of around $1.157 billion. Ten years ago, these figures stood at 43 firms employing 6700 persons, with annual sales at $97 million.

Although it would be impossible to list all the electronics firms doing business in this area, some of the "giants" of the industry with facilities here are: **Acoustica Associates,** with 65,000 square feet and 400 employes; **Amelco, Inc.,** with 105,000 square feet and 600 employes; **American Electronics, Inc.,** 353,596 square feet and 1450 employes; **Autonetics,** over 1 million square feet and 9000 employes; **Bendix-**

FRONT VIEW of buildings in Hughes Aicraft Company's new ground systems group, located in gently rolling terrain of the former Sunny Hills Ranch at Fullerton.

Pacific, 420,000 square feet and 3000 employes; **Cannon Electric Co.,** 300,000 square feet and 2900 employes; **Collins Radio,** 131,754 square feet and 700 employes.

Elgin National Watch Co., Electronics Div., 30,000 square feet and 500 employes; **Hoffman Electronics Corp.,** 770,000 square feet and 3350 employes; **Hughes Aircraft Co.,** over 5 million square feet and 32,168 employes; **Kearfott Co., Inc.,** 60,000 square feet and 350 employes; **Leach Corp.,** 143,255 square feet and 708 employes; **Lear, Inc.,** 55,000 square feet and 587 employes; **Litton Industries,** over 1.2 million square feet and 12,000 employes; **Pacific Automation Products, Inc.,** 150,000 square feet and 900 employes; **Packard-Bell Electronics Corp.,** 500,000 square feet and 2400 employes; **Radio Corp. of America,** 165,000 square feet and 1000 employes; **Rheem Mfg. Co.,** 625,337 square feet and 2500 employes; **Servomechanisms, Inc.,** 20,000 square feet and 300 employes.

Two of the larger facilities under construction are those of Lockheed and Thompson Ramo Wooldridge, Inc. in San Fernando Valley, where the sites run into hundreds of acres.

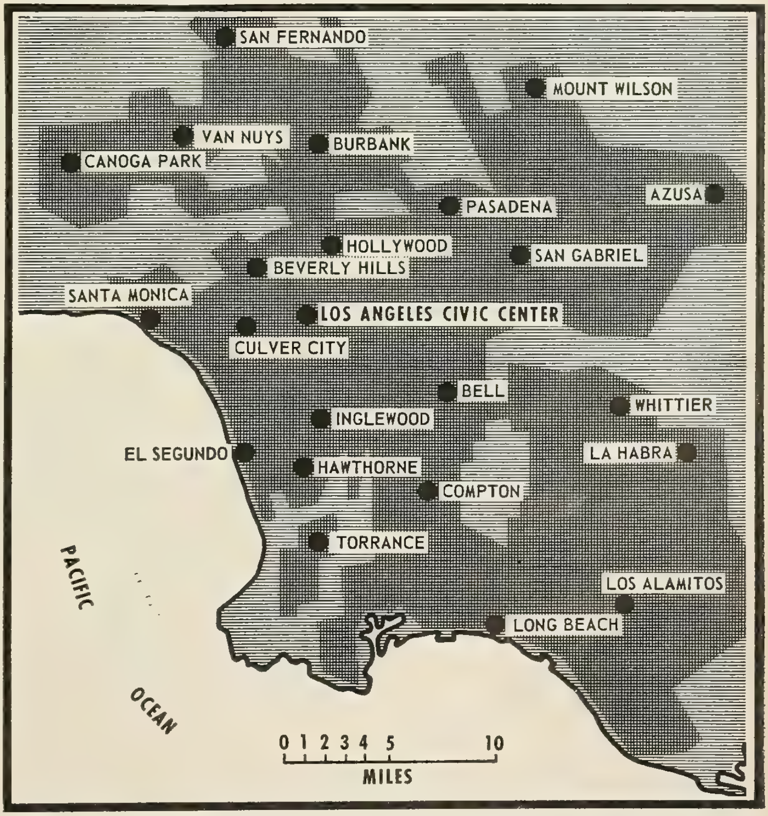
- **Unusual construction**—Lockheed's California Division Research Center ultimately will occupy a 200-acre site near Saugus in the valley's San Gabriel Foothills. The center, first phase of which will cover 65 acres, was designed by **William L. Pereira and Associates,** and features an unusual set of construction techniques. The buildings to be constructed first will be based on a 48-foot module, with movable partitions and high bays for quick conversion into offices, shops, or laboratories. Each building will also be capable of external expansion to meet future requirements.

The second, more unorthodox feature of the Lockheed center is its utilization of surrounding natural canyons to provide high-bay, noiseproof future quarters. By spraying the canyon walls with gunite to stabilize them, roofing over the canyon with a slab containing all utilities, and installing flooring, it will be possible to use the chambers as multi-story buildings. This will eliminate the need for large scale earth-moving operations. In an interesting understatement, the architect says the plan will result in "an unprecedented example of integration of site and structure."

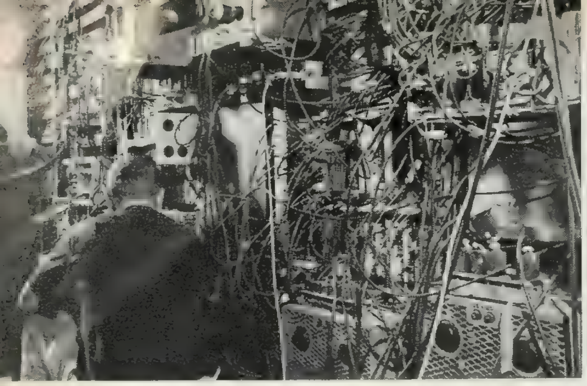
When completed, the center will accommodate two wind tunnels capable of Mach 10 velocities, environmental test chambers simulating space conditions, a computer center, radar antenna range, and facilities for research in physics, chemistry, physiology and all other fields related to atmospheric and space flight, as well as various service facilities.

- **Breathing room**—The new TRW laboratories at Canoga Park will house the Ramo-Wooldridge Division, Thompson Ramo Wooldridge Products Co., and the corporate west coast headquarters of Thompson Ramo Wooldridge, Inc. Designed by **Albert C. Martin & Associates,** TRW's laboratories will be occupied by November and represent another example of the campus-style design now in vogue. The LA quarters will be taken over by STL.

About 2300 will be employed at the new laboratories—many moving with the company from its present LA site, and some being employed from the new locality. TRW gave cramped LA quarters as a prime reason for the move into San Fernando Valley. Although still within Los Angeles City Limits, the 90-acre site gives more "breathing" room. Total floor space of the buildings will be about 810,000



SOME OF the main industrial centers in the Los Angeles area. Eventually, the continuing merger of communities is expected to create a single city 200 miles long.



COMPLEXITY OF equipment produced by Mincom Division of Minnesota Mining and Manufacturing Co. is indicated in this photo. Mincom is expanding.

square feet upon full development. Approximate construction cost will be $15 million.

A 63-acre site just north of the brand-new Ventura Freeway has been bought by Litton Industries, Inc. in San Fernando Valley, to house its Electronic Equipments Division. Designated the Woodland Hills-Canoga Park facility, the new buildings will house research, development and production activities. The company's Tactical Systems Laboratory is moving into quarters at the north end of the site, and the main building will be built at the south end.

The facility is being designed by Albert C. Martin & Associates in an industrial-park arrangement. In fiscal year ending July 31, 1959, Litton did $125 million worth of business, compared with the preceding year's $83 million—a 50% increase.

Packard-Bell Electronics Corp. has leased 50,000 square feet in the valley to house the ACRE-Octopus portion of the *Polaris* ground-checkout program. Meanwhile, the company is breaking ground on the first 50,000-square-foot unit of its new plant in Thousand Oaks, Ventura County, to be occupied in early 1960.

Cooper Development Corporation's effort is toward more efficient utilization of present space, with increases in professional personnel. CDC has jumped about 20% in personnel, and is concentrating its expansion program on the R&D side of its activities. The company had the best first quarter in its history this year, receiving about $2 million in orders. A super-*Asp* development is now on the drawing board, as well as a multi-*Asp* design.

Consolidated Electrodynamics Corp. recently opened a new Western Regional office for its wholly-owned subsidiary, **Consolidated Systems Corp.,** and the constantly expanding personnel of the parent corporation eventually will require more space. CEC has, however, one mostly vacant building into which it can funnel any expansion, and no planning for new buildings is under way at present. The company now has about 3000 employes.

The new CSC subsidiary has established three field offices (Washington, D.C., Atlanta, and Monrovia, Calif.) as the nucleus of a field engineering organization. The CSC custom-engineered instrumentation products will be aimed at the aircraft/missile, nuclear energy, petroleum and chemical industries.

The new Canoga Park R&D complex of Atomics International will consist of two two-story buildings of 106,500 square feet each. One will be used as a laboratory, the other for engineering and administration. A one-story building of 30,000 square feet will house service groups as cafeteria, personnel, security and clinic. A 135,000-square-foot building is already on the site.

Still another project of Albert C. Martin & Associates, the complex will cost about $4 million and is scheduled for completion by Dec. 31.

Gilfillan Bros., Inc., with a brand-new plant adjacent to its executive offices, now has seven plants in the LA area. The new $350,000 building will quarter engineering and publications activities.

A large building program is also under way at the Marquardt Corporation, where a $1.25-million engineering and administration building for the firm's Power Systems Group is under construction in Van Nuys. A building of similar scope is planned for the Pomona Division, formerly **Associated Missile Products Co.,** before its acquisition by Marquardt. The firm's combined operations now employ about 5000 persons and occupy nearly a million square feet of space, not including the current construction.

AiResearch Manufacturing Division of the **Garrett Corporation** has started construction of a $2.6 million facility on a 66-acre site at Torrance. The building is the first in a million-square-foot complex and will contain 235,000 square feet in a two-story building for development and manufacture of electrical and electronic central air data equipment. Between 600 and 800 employes will be transferred to the Torrance site from the company's present location in six to eight months.

One major aircraft manufacturer, Lockheed, is on the upswing with its missile division. While not expecting any spectacular changes in the next year, LMSD at Van Nuys will gradually expand its personnel, rising from a low point of activity during the past year. The division's Van Nuys activity will attempt to develop some strong projects of its own, and will concentrate on high-speed, high-altitude target drones.

The group will handle engineering, design, manufacture and other aspects of drones such as *Kingfisher,* "which has taught us a lot, and we hope to be able to build up a good target business." In research vehicles, LMSD-Van Nuys anticipates more work on such projects as the *X-17,* which did so well in reentry work, and the *Argus* project. From the present level of 3100 employes, the division plans to increase to 4000 by the end of the year, and an eventual maximum of 4500.

Telecomputing Corporation, a family of six firms, has expansion plans in automation—both military and industrial. It anticipates building up its ability to weather seasonal fluctuations in business, and will improve test facilities, as well as finance research and development projects based on sales trends. TC is comprised of **Whittaker Controls, Whittaker Gyro, Brubaker Electronics, Data Instruments, Nuclear Instruments,** and **Engineering Services.** These six organizations have a combined work force of 2155, including 500 engineers. Total floor space occupied by the group is about 500,000 square feet.

The Mincom Division of Minnesota Mining and Manufacturing Co., a new, small, and rising star in the 3M family, is producing complex recorder/reproducer equipment for telemetry application, and is expected soon to introduce a new system. Established as a 3M division in 1956, the group was the first to develop tape recorders for wide-band instrumentation applications. Now in a period of rapid growth, the division is pioneering its Isoloop tape-transport system for telemetry recording and reproducing, which minimizes wow and flutter to 0.1% peak, measuring all components from 0.1 to 4000 cycles.

Although much of the missile business is wrapped up by airframe companies, new programs, facilities, and enthusiasm are being provided by the electronics-oriented firms, and those organizations with extensive investments in all types of research facilities.

Today's Gyros Won't Do Tomorrow

Recent advances keep missile guidance gyros up to present demands but significant progress is needed for operational missiles and spacecraft

by Hal Gettings

WASHINGTON—An estimated $620 million is being spent on missile guidance and control this year. Of this total, about one-third—over $200 million—goes for gyroscopes. Consequently, the development and production of these ultraprecise gadgets has a big place in the missile industry.

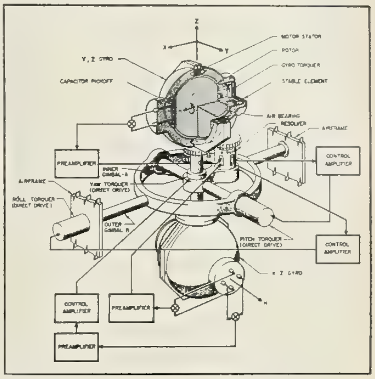
At least 14 large companies and many smaller ones are involved in the gyro and guidance business. **Sperry Gyroscope, Minneapolis-Honeywell (Military Products Group), Kearfott,** and **Bendix (Eclipse-Pioneer)** are the leaders in gyro development and manufacture. Other important firms include **Giannani, Norden-Ketay, U.S. Time, Whittaker,** and **Summers.**

Three of these firms—Honeywell, Kearfott, and Sperry—are also prominent in guidance system production, along with **North American (Autonetics), AC Spark Plug, Arma, Litton,** and **Bell Aircraft.**

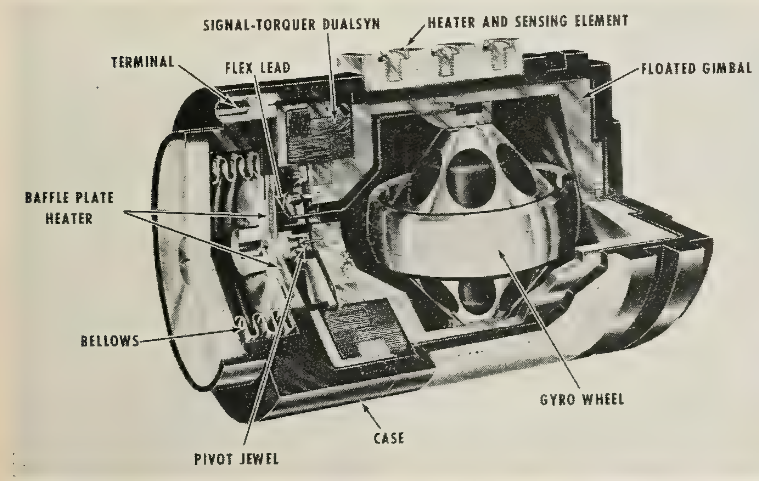
The average missile inertial guidance platform contains a minimum of three gyros. The stabilization package also contains three. Others may be used as accelerometers. In addition, the fuzing and arming system may contain one to three gyros. So a complete missile system may require from $10,000 to $50,000 worth of these sophisticated toys.

Gyros are expensive—up to $12,000 each—because of the fantastic precision with which they must be manufactured. For example, a shift of one microinch in wheel position of a gyro can cause a drift error of 0.03°/hr. Such an error could mean the difference between success and failure of a moon shot.

Obviously, an inaccurate guidance system is about as bad as no system at all; accuracy is the prime goal of a gyroscope. And cost goes up right along with accuracy. Much current research is aimed at obtaining required precision without making the units prohibitively expensive.



"FREE-ROTOR" gyro developed by Autonetics may make guidance platforms simpler, stabler. Two replace usual three.



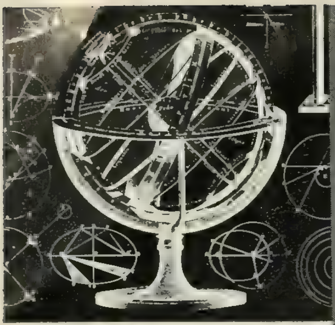
CUTAWAY of a miniature integrating gyroscope shows its complex construction. A chief aim of research today is to achieve precision without prohibitive cost.

• **Problems**—Manufacturers generally feel that gyros are equal to the job that they're called on to perform today. But today's gyros won't be able to do tomorrow's job. The industry must see considerable improvement if it is to meet the multi-stage guidance systems required for long-range interplanetary and interstellar missions. There is confidence, however, that the challenge will be met.

Areas most heavily researched at present include accuracy, friction, size, spin-bearing design, and pickoff techniques and components. Reliability is the thorniest problem of them all. This, of course, is interrelated with the problems of accuracy and friction and the requirement for smaller and smaller units. Warmup times must be decreased to meet the demands of operational missiles.

New Developments

Theoretically, only an entirely frictionless gyro would be 100% accurate. Consequently, much research has gone into the problem of friction and constancy of the motor and gimbal bearings. Gas- and air-bearing suspension has been developed to a point approaching the ultimate, but further progress comes hard. "Floated" gyros



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—in which the inner gimbal is a can suspended in a liquid—are used extensively in missile guidance for their near-frictionless operation. The flotation liquid brings its own problems, however, in temperature-sensitive viscosity coefficients and density.

• **Electrical suspension**—Probably one of the most significant recent advances in gyroscope technology is that electrical suspension has been proven feasible. Honeywell has been researching this area for several years under contract to Navy Bureau of Ordnance and announced only this month the successful development of a prototype model. The unit uses a beryllium sphere rotor suspended electrically in a vacuum. No figures are available but the company claims potential accuracies far beyond the capability of conventional units.

• **Flotation fluids**—Sperry has developed a new "Gyrolube" bromo-carbon flotation fluid that reduces warmup time by about 50% and eliminates danger of gyro damage upon cooling. Developed for the B-58 guidance system, the fluid has a relatively flat viscosity rating over a wide temperature range down to less than –65°. Its successful use in floated gyros—the primary type for missile guidance—would do much to simplify operation. Conventional chloro-fluorocarbon compounds require that the gyro package be maintained at a constant temperature and need relatively long warmup and runup times. Heater failure can knock out the entire guidance system.

• **Unheated floated gyros**—Norden-Ketay has found another approach to the heating problem of floated gyros (M/R, Feb. 16). They have patented a "buoyed rate gyroscope" which achieves temperature compensation mechanically. The thickness of the flotation liquid film between the inner and outer cages is varied by a bellows arrangement which effectively changes the cage diameter in response to temperature changes.

• **Spring-powered gyros**—Several companies have developed units energized by "clock" springs. **Whittaker Gyro Division of Telecomputing Corp.** has one model which operates for 30 seconds and others designed for up to ten minutes of flight. Runup time is less than ten milliseconds. Once wound and armed at the factory, the spring-energized models can be stored for indefinite periods without loss of accuracy. **Waltham Precision Instrument** has announced one unit which sells for less than $200.

• **Gas-driven units**—Honeywell has developed an expendable two-axis gyro which is directly competitive with the spring-powered unit. This is a compressed-gas energized gyro with a drift rate of 0.5°/min. It weighs less than four pounds and has a predicted reliability of 0.988.

• **Free-rotor gyroscope**—A unique "free-rotor" gyro for guidance application has been designed by Autonetics. In this unit, the spherical rotor is supported and turns in a gas-lubricated bearing—with practically no friction. Overall mechanical assembly is less complex and gimballing and flotation of the rotor assembly is not required.

Only two of these gyros are needed to furnish 3-axis platform stabilization. A simple second-order type control servo system is sufficient, with inherently more stable characteristics and less complicated electronic circuitry.

• **Ferrite applications**—Kearfott—and possibly others—have successfully used ferrites as stators and rotors in floated gyros and look for expanding applications as gyro size is reduced. With conventional laminated stacks there are problems in maintaining good mechanical design and stability as laminations are made thinner. And the laminated stacks have been known to deteriorate in the flotation medium.

Ferrites are mechanically inert and do not require laminating with organic material. Consequently, their electrical and mechanical properties remain constant with time. In addition, the specific gravity of the ferrite is only 60% that of the laminate; suspending media of lower specific gravity—and corresponding low viscosities—can be used.

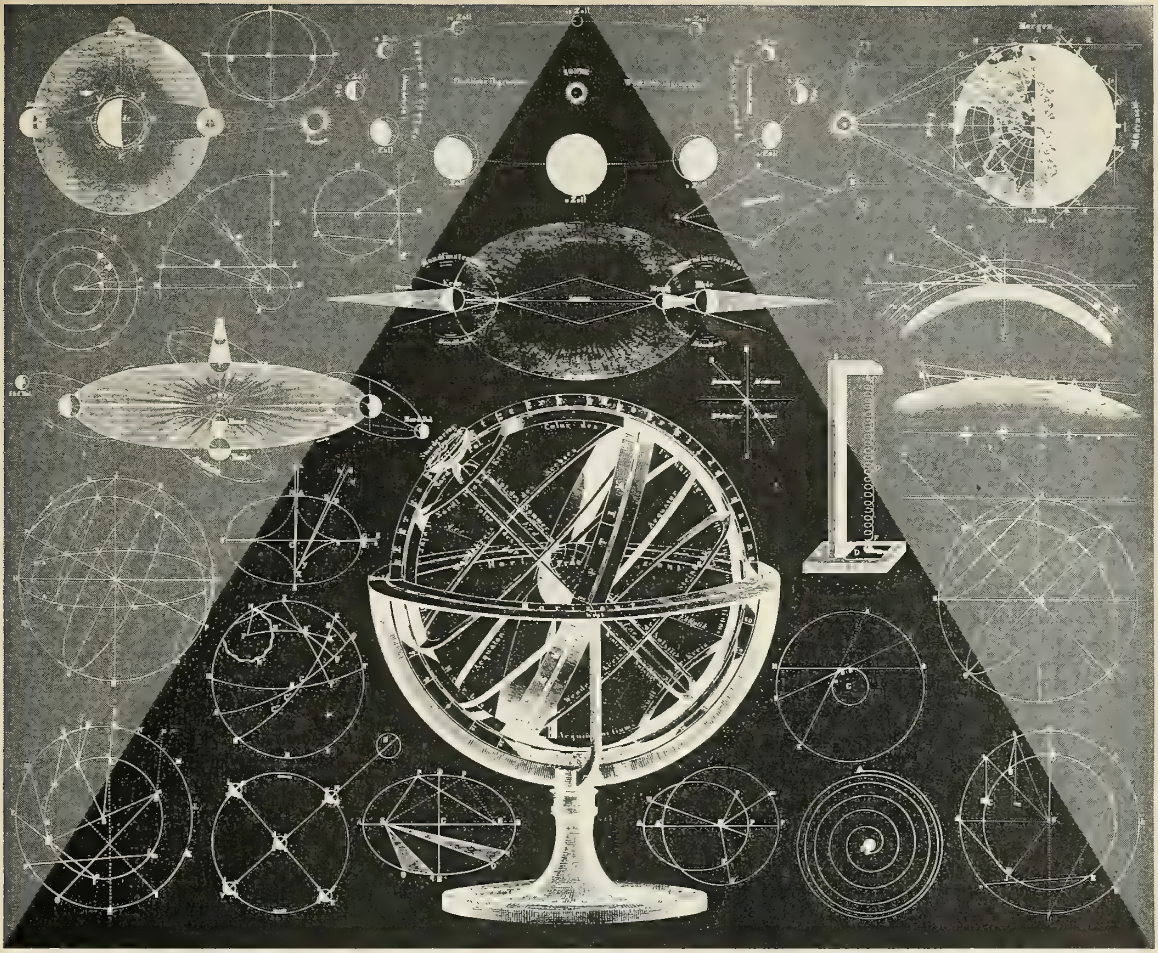
• **Bearing improvement**—Sperry Gyroscope, in a research program into the cause of gyro failures, discovered microscopic residual abrasive particles imbedded in the races and ball bearings of gyro assemblies. These particles were identified as the cause of many cases of bearing wear leading to drift and eventual breakdown.

To eliminate these particles, Sperry evolved a new (and undisclosed) method of assembly that precludes any contamination of parts. The resulting "Wear-less" gyro units have reportedly been run in tests for several thousand hours with no sign of wearing.

Company engineers have also developed "unitized" wheel-bearing assemblies in the quest for better accuracy. Such construction makes the bearing races part of the shaft and supporting structure. Gyros using this technique are now in production.

• **Future developments**—Work is continuing on many aspects of gyro progress. Some are already yielding worthwhile advancements; others are still in the future.

Gas bearing and supplementary suspension, as well as ball-bearing improvement, are getting attention from nearly all firms in the business.

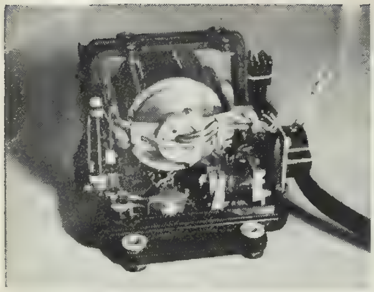


Guided tour of the solar system

The new NASA Thor-boosted research rocket, DELTA, now being constructed by Douglas, will set up big signposts for further space explorations. Combining elements already proved in space projects with an advanced radio-inertial guidance system developed by the Bell Telephone Laboratories of Western Electric Company, DELTA will have the versatility and accuracy for a wide variety of satellite, lunar and solar missions. Douglas insistence on reliability will be riding with these 90 foot, three-stage rockets on every shoot. At Douglas we are seeking qualified engineers to join us on this and other equally stimulating projects. Some of our requirements are listed in our column on the facing page.

Maxwell Hunter, Asst. Chief Engineer—Space Systems, goes over a proposed lunar trajectory with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT



NEW RATE GYRO developed by Minneapolis-Honeywells Aeronautical Div. combines new design, ruggedness.

PROTOTYPE of Minneapolis-Honeywell's electrically-suspended gyro. Beryllium rotor is suspended in a vacuum.

Beryllium—because of its desirable low density, high rigidity, and low coefficient of expansion—is being thoroughly researched for use in wheels and gimbals.

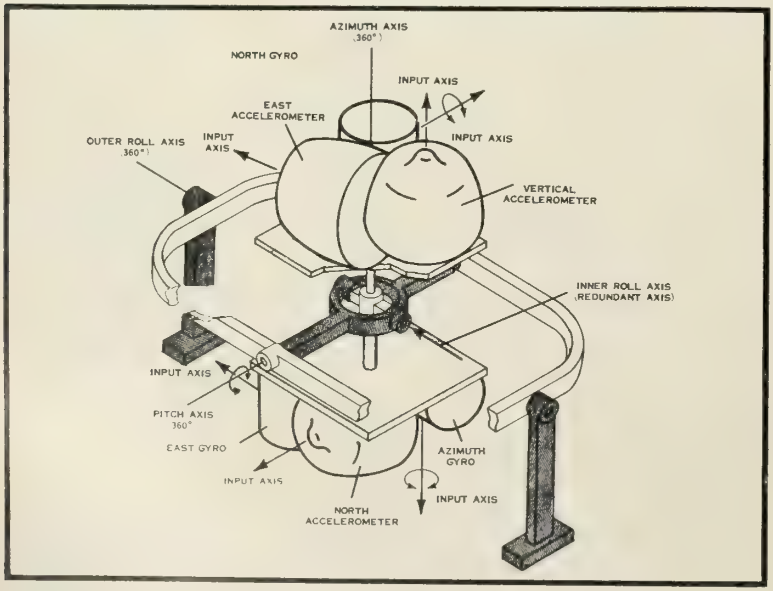
Several manufacturers are carrying on a continuing program for development of better flotation fluids. This has produced some significant results but the ultimate that can be stored and operated unheated over the full temperature range is yet to be attained.

Other research is aimed at decreasing power requirements and achieving longer operation cycles, shorter runup times, longer shelf life, and, of course, lower costs.

• **Buying procedures** — Guidance system specifications are usually set by the missile procuring agency. In some cases, the missile prime contractor may have this responsibility. For Air Force missiles, **Space Technology Laboratories** usually determines specs. Both ABMA and JPL have a hand in Army systems. Navy requirements are set by Special Projects Office and MIT. In general, broad operating parameters are set by the buyer and operating characteristics by the guidance designer.

• **Lack of standards**—Perhaps the biggest problem facing the industry is the fact that there are few or no standards for defining accuracy. This most important characteristic is measured, usually, by the tendency of a gyro to "drift". This tendency is not so much of a problem if it is a constant and predictable value. Establishing this value, however, is what keeps gyro designers and specifiers awake nights.

Drift is classified both by amount (displacement) and by rate. The latter is the more commonly used but here, again, standards are lacking as to methods and conditions of measurement and calibration. The sad fact is that the drift rate curve lends itself to varied interpretations.



SCHEMATIC of inertial platform shows essential elements of any "pure" inertial guidance system: 3 accelerometers, 3 hermetic integrating gyros and gimbals.

The overall problem was pointed out recently in a survey sponsored by Aerospace Industries Association. Hope is for better coordination by industry —led by the National Bureau of Standards—in setting up realistic standards and calibration techniques. This would be of inestimable value to gyro and guidance manufacturers.

• **Drift rate terminology**—Drift is commonly defined in four different categories:

1) Gravity-insensitive (degrees/-hour).—Caused by fixed unbalance torques which produce a steady-state error signal.

2) Gravity-sensitive (degrees/-hour/g).—Caused by mass unbalance around output axis. Varies as a function of acceleration.

3) Anisoelastic (g^2-sensitive drift). —Caused by inequality of elasticity of mass support along the input axis and along the spin-reference axis. Develops torque on the gimbal.

4) Random drift rate.—Non-controllable drift caused by uncertainty torques due to bearing, temperature gradients, etc.

In the case of gyros, many parameters must be defined relative to the accuracy measurements: platform orientation, environmental conditions, power inputs, number and duration of runs, and any number of variables that might influence test results must be considered. A unit, for instance, that is perfectly satisfactory for a ballistic missile—where moderate drift rate is not serious—would not do at all for a long-duration space vehicle.

It has been suggested that the biggest consideration in accuracy definition is that the acceleration-sensitive coefficient be small, and that this should be used as a yardstick of gyro performance. A further proposal involves a complicated procedure of integrating and replotting the drift rate curve in terms of drift angle versus elapsed time. By analyzing and summarizing the variations of accumulated angular error over the entire curve, a family of curves can be generated for displacement error—maximum, rms, and average—versus elapsed time.

One interesting technique for measuring gyro drift is being used by **Martin Co.** engineers (M/R, Jan. 19) for the *Mace* guidance system. Since the torques involved are so small and can be measured only with the gyro completely assembled, the method, in effect, uses the gyro to test itself. The earth's rotation and gravitational field are used as stable inputs. Total angular motion reported by the gyro in a given time period is compared with the actual motion of the earth in the same time. Difference between the two is due to the drift rate of the gyro.

Hughes Research Reveals Advances In Infrared Detection Techniques

Shielding technique doubles IR search and tracking range; cooling methods treble the detectivity of IR cells

SANTA BARBARA, CALIF.—Significant performance improvements have been achieved with lead-selenide infrared detectors by employing new shielding and cooling techniques, according to **Hughes Aircraft Company.**

The developments have resulted from IR detector-cell studies performed here at the company's Santa Barbara Research Center.

- **Shielding**—One recent discovery at the Research Center pointed the way to improved performance of lead selenide detectors. It was found that detectivity is limited by ambient or room temperature radiation falling on the sensitive film. Although this effect is not new in the detector field, the company believes it had not been demonstrated previously with lead selenide.

By providing appropriate shielding in the detector package, improvements in detectivity of a factor of six to ten have been achieved. The shielding is designed to fit the optical system, since the improvement in detectivity is inversely proportional to the sine of half the angle subtended by the aperture at the detector. For example, with an f/2 system, proper shielding offers improvement of a factor of four, relative to the standard package performance.

Also, this improvement is attained by an increase in signal and noise level so that the shielded detectors are easier to use with conventional amplifiers. The time constant becomes longer with shielding; however, detectivity increases with frequency up to the frequency at which the signal begins to fall. Above this frequency, the detectivity drops about 2 db to 8 kc.

Another technique of restricting the amount of ambient radiation involves the use of spectral filtering. Selective filters on the detectors absorb light of wavelengths which are not contained in the signal radiation.

The results of employing these techniques are illustrated in Fig. 1: curve A is for a standard unshielded detector; B is for the same detector shielded for an f/6 system; and C is the same as in B with a quartz filter added. This detector was 3 x 3 mm^2 in area and was fitted with a sapphire window. The measurements were made at liquid nitrogen temperature (less than –195.8°C, sea level) at 780 cps with a bandpass of 1 cps.

Sizable improvements in system sensitivities can be obtained by taking advantage of these improved detectors. For example, the range of operation of a search and track system under development at SBRC was doubled when the former detectors were replaced with the improved version. To achieve optimum performance, it is necessary to design the detector package coincident with the system because of the detector dependence on optical speed and spectral filtering.

- **Cooling**—Cooled IR detectors

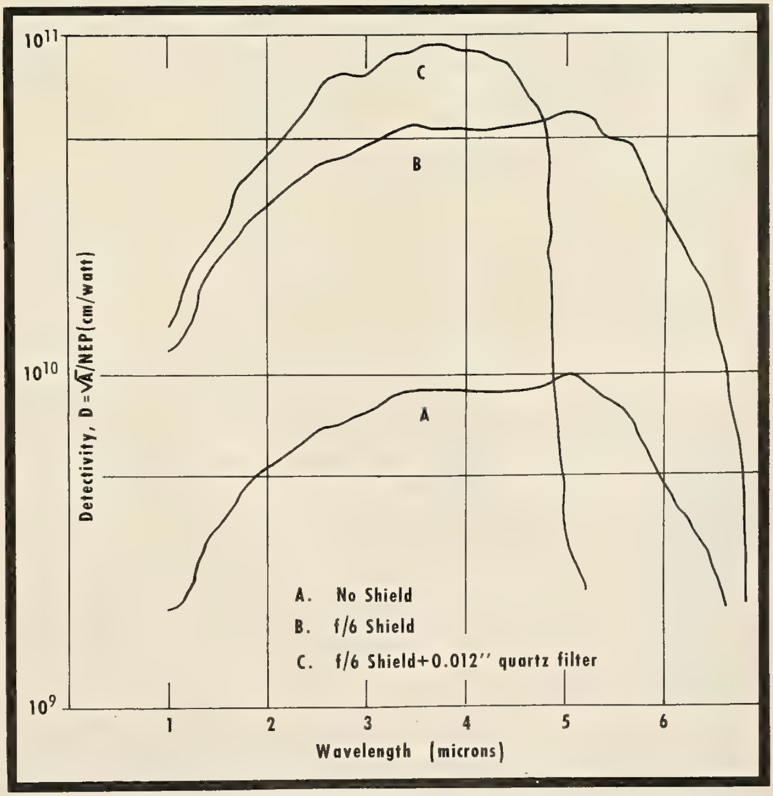


FIG. 1—A comparison of results using shielded and spectral filtered lead selenide infrared detectors. Measurements were made at liquid nitrogen temperatures.

have grown from laboratory tools to full-fledged components in missile systems. Because of this, there has developed an urgent need for a rugged, practical system of refrigeration to liquid N_2 temperature. The Research Center has developed several solutions to this problem with emphasis on engineering the system to operate automatically in the airborne environment.

The most satisfactory systems, SBRC believes, are Joule-Thompson coolers. Two types of these are operated on demand either by a liquid-level sensor or by pressure-regulated liquid transfer systems using uninsulated transfer tubing.

The first type of Joule-Thompson system is illustrated in Fig. 2. Compressed gas A, at about 2500 psia initial pressure, is transferred by capillary metal tubing through filtering unit B. Filter B removes particles and gases condensable at higher temperatures to a special solenoid valve C. When valve C is opened, gas flows through the Joule-Thompson cooler D, which is mounted in the inner tube of the detector dewar, and liquefies upon expansion.

A unique feature of this system is a germanium sensor placed just above the end of the dewar tube. When the liquid level drops, the germanium sensor rapidly becomes conducting and actuates the solenoid valve to restore the flow of gas.

By proper design of the Joule-Thompson cooler and the use of absorbent material in the dewar tube, the entire system may be operated upside down or at any altitude. The use of the automatic metering system assures economical operation, according to SBRC. This system has been flight tested successfully and its use is recommended for applications involving long standby times.

For installations in which weight and space are at a premium, the direct liquid transfer Joule-Thompson system offers a number of advantages. After some months of research, it has been determined that uninsulated tubing may be used for the transfer of liquid N_2 without excessive loss. The tubing material and size are critical, but may be varied within limits to suit the requirements of individual installations.

Fig. 3 illustrates one of several types of liquid transfer systems which have been developed (the system illustrated has been subjected to extensive actual and simulated flight testing). In the supply vessel, which is connected to the detector flask by a small-diameter uninsulated tube, is an electrical heater element. The supply of energy to the heater is controlled by a pressure-actuated switch using ambient pressure as a reference. An over-pressure relief valve is also provided, and this, too, uses ambient pressure as a reference.

In the head of the detector flask is a calibrated orifice through which gas generated by the evaporation of liquid in the flask is vented, also to ambient pressure. Typically, the pressure switch may be set to open at 4.5 to 5.0 inches Hg (mercury) above ambient pressure; the relief valve may be set to open at 5.5 to 6.0 inches Hg above ambient pressure. Any increase in rate of liquid N_2 flow above that for which the system is calibrated will increase the pressure difference across the orifice, will raise the system pressure, and so will open the heater control switch.

By using ambient pressure as a reference, the absolute pressure in the system, and so the temperature, will be lowered at high altitudes. According to SBRC, this is of peculiar advantage in cooling detectors such as gold-doped germanium which show improvements in detectivity by as much as a factor of three if they are operated at a temperature just above the freezing point of liquid N_2.

A typical liquid transfer unit would weigh 7.5 pounds complete when filled with liquid N_2. The company said it will cool a complicated eight-detector package for more than 6 hours under in-flight conditions and after a standby time of 24 hours.

Courier Satellite Will Lead to Global Network

New York—The Project *Courier* communications satellite—scheduled for launch in early 1960—will be able to transmit six million bits of information in four minutes. The 500-lb. ARPA satellite will be the first step in establishing a global communications network for the free world's armed forces.

The system, under the technical direction of Army Signal Research and Development Laboratory, is designed to provide 20 continuously available 100-word-a-minute teletype channels to relay messages transmitted between ground stations. As the satellite passes over one station, it is commanded to transmit information "addressed" to that station. Simultaneously, the satellite records, for later transmission, traffic for other stations in the network.

The 28-foot antenna systems and associated instrumentation will be built by **Radiation, Inc.** under a recently awarded $1,283,000 contract. Ground terminal equipment is being designed by **ITT Laboratories. Philco Corporation** is responsible for communication relay equipment in the satellite.

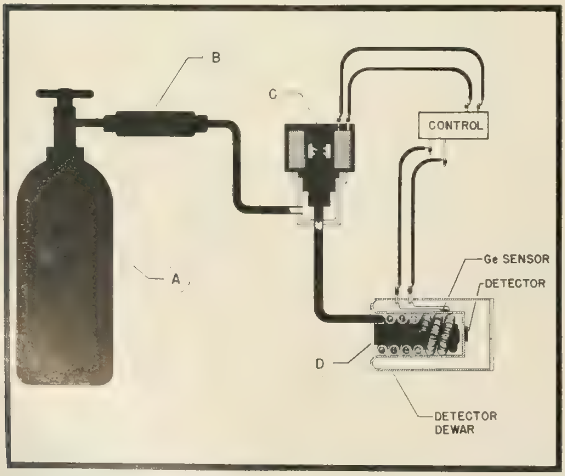


FIG. 2—Flow diagram of a typical liquid-level sensor Joule-Thompson refrigeration system for IR detectors.

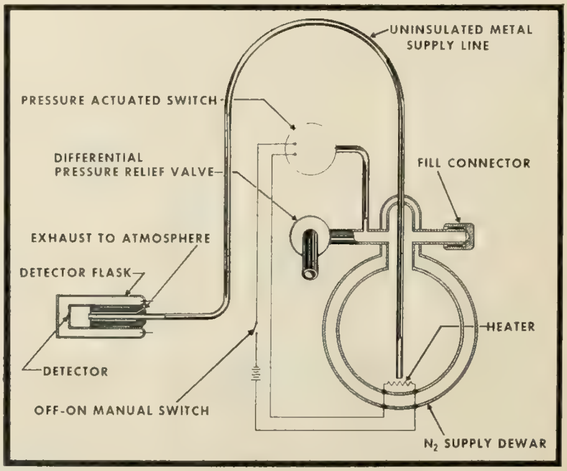


FIG. 3—Diagram of a direct liquid N_2 transfer system for IR detectors by Santa Barbara Research Center.

as an adequate minimum . . .

ARPA Wants $550 Million for '61

Principal problems are lack of money and project bottleneck resulting from intramilitary squabbling. Last of a series on Pentagon planning.

by James Baar

WASHINGTON—ARPA—spawn of the sputniks and director of military space research and development—is moving toward its second anniversary stronger than ever but beset by two major problems.

One is money. The other—somewhat mitigated—is the intramilitary struggle over space missions.

The first stems directly from the freezing of the defense budget by the Administration at $40 billion or less for another year. The second stems directly from the failure of the Joint Chiefs of Staff and the Defense Department until now to assign developed space projects to particular services for operation. Assignments now being passed out by the Joint Chiefs are expected to ease the situation—at least temporarily.

Both in one way or another have affected ARPA plans to push forward next year with dozens of advanced R&D space projects ranging from *Discoverer* satellites and the huge *Saturn* clustered booster to the search for new materials for the Missile Age.

But most signs are that ARPA as an organization will continue to flourish. In fact, there are expectations that the Defense Department may soon assign it some new advanced R&D projects well outside the field of space.

This non-space role is one in which ARPA sees much of its future. Even today about 40% of its money goes for non-space projects.

As for ARPA's major problems, let's look at money first.

• **Fiscal uncertainty**—ARPA appears ready to fight for about a $550-million slice of the frigid $40-billion defense budget pie which the Administration plans to serve up to Congress for FY 1961. That's about $95 million more than ARPA asked for—and got—from Congress for FY 1960.

But the chances of the Administration agreeing on even $95 million more for ARPA next year offer no safe bet. Moreover, there is considerable sound argument in favor of ARPA's need for at least several hundred million additional dollars.

The extra money would be used for the most part to speed up work on ARPA projects across the board. It would enable more extensive experimentation, more rapid collection of data and in many cases more rapid arrival at conclusions. In turn, this would lead in many cases to speedier development of vital projects.

A prime example of the direct effect of funding on progress is Project *Defender*—ARPA's highly classified and highly complex search for an advanced anti-missile missile system more effective than **Western Electric's** *Nike-Zeus*.

Work on *Defender* next year will involve continuation of the collection of vast amounts of data on the behavior of ICBM's in flight and related physical phenomena.

It also is expected to involve some small-scale experimentation on the feasibility of various AICBM concepts. Here is the rub.

• **Limited choice**—Such experimentation—on any scale—is extremely costly. Although the price tag varies from case to case, tens of millions of dollars are generally called for.

Obviously, therefore, a limited budget greatly limits what can be done. It is not possible to choose between possibly good and possibly bad concepts for experimentation. ARPA must choose between the possibly good and possibly very good.

However, top ARPA officials are understood to feel that—within the context of the frozen $40-billion defense budget—an increase of ARPA's share to about $550 million would be adequate.

They are understood to argue that the return on money spent beyond this point on ARPA projects probably diminishes—particularly when the money must come from the hide of some other part of the defense structure.

But that doesn't mean the pinch isn't being felt.

For instance, ARPA had scheduled five *Transit* navigation satellite launchings: one this fall and three next year. And no plans are being made to change this schedule even though the first launching attempt on Sept. 17—all but failed because of trouble in the third stage of the *Thor-Able* rocket, a vehicle used successfully many times before—and not in the satellite.

• **Pentagon bottleneck**—The squabble over who gets what ARPA project has centered in the Office of the Secretary of Defense and the Joint Chiefs of Staff.

ARPA would like to see each of its projects assigned to a military service for operation two years before development is completed.

The policy behind this is to meet service criticisms that the ARPA system overlooks the need for designing a military system to meet the requirements of the service using it.

Unfortunately, in moving to meet this criticism, ARPA has run into the interservice space fight that centers at the Pentagon's top military levels.

The Air Force continues to insist that space—unlike Gaul—is not divided into three parts. But the Army and Navy insist Caesar applies in both cases.

The result has been a stalemate of increasing seriousness.

• **Jobs unwanted**—To date only one ARPA project—the satellite detection fence that stretches across the southern United States—had reached the point where assignment is overdue. But in a matter of months the list would have been much longer.

Continued delay in assigning projects would force ARPA to retain them—a role it does not want. Among other things, retaining them would violate ARPA's management system based on operating with a small, highly trained, flexible staff of about 80 members who provide overall direction to the services, universities and private companies handling ARPA projects.

• **The big four**—The biggest of these projects are *Saturn, Discoverer, Defender* and *Samos.*

Saturn, under development at the Army Ballistic Missile Agency at Huntsville, Ala., is expected to be operational about early 1962. The clustered 1.5-million-pound-thrust engine is scheduled to be the military workhorse for putting large payloads such as space stations into orbit.

ARPA considers *Saturn* a key to major military space missions. It plans to spend nearly $70 million on it in FY 1960.

Discoverer is an open-end program that will involve increasingly larger payloads and boosters. By the end of 1960 **Convair** *Atlases* may well be substituted for the **Douglas** *Thors* now being used. The ARPA FY 1960 budget includes some $60 million for *Discoverer.*

The *Thor* with the **Lockheed** *Agena* second stage in six launchings already has generally accomplished a major part of the early *Discoverer* series objectives. All three of the *Discoverer* satellites that have been placed into orbit have been successfully stabilized —the necessary forerunner to successful development of *Samos* and *Midas,* the ARPA-Air Force reconnaissance and early warning satellites.

However, bio-medical capsules ejected from all three satellites were never recovered. Further progress in the *Discoverer* schedule including the probable orbiting of monkeys is being delayed until the recovery system is perfected.

Officials now attribute the failures to date—particularly those of the capsule—to a breakdown of unnamed equipment including the capsule's radio. Another recovery attempt will be made with the launching of *Discoverer VII* late next month.

Defender—a drive to find the AICBM of the 1970's—probably will expand its activities during the next year to the Pacific to collect data on ICBM and IRBM firings from the Pacific Missile Range.

Two data-collecting ships—the American Mariner and the Arcania—already are operating in the Atlantic Missile Range. A ship or island data-collecting bases, or both, probably will be established in the Pacific—particularly to monitor *Nike-Zeus* and **Lockheed** *Polaris* tests.

Defender is scheduled to get more than $128 million of the current ARPA budget.

Samos—budgeted this year for $100 million—is potentially one of ARPA's most controversial projects. Little is said publicly by military and civilian officials about what the international political consequences of orbiting reconnaissance satellites may be.

Russia is known to be pushing development of a reconnaissance satellite as a top priority project. The first R&D *Samos* is expected to be launched about early March.

• **Nuclear deadend**—One of the smaller but most important of ARPA's projects—*Orion*—may be nearing a dead end before next year is out.

General Atomic's *Orion* is a study aimed at possible development of a nuclear blast-propelled rocket. The firm will continue its studies for another year under a recently renewed $1-million contract.

But the point may well be reached by the end of next year where work can no longer proceed without nuclear tests which currently are banned at least until Jan. 1.

ARPA sees much promise for *Orion* as the most efficient big rocket of the future—possibly the rocket that will be the basic booster for military missions not only on this side of the moon but far beyond.

At present, all such areas are officially designated as non-military scientific provinces where no military mission abides. However, with the successful flight of *Lunik II,* how much longer such a policy will be tenable is very much open to question in the minds of many inside and outside the government.

Cheaper Epoxy Nose Cone Material Survives 5000°F

PHILADELPHIA—An epoxy resin heat shield material for nose cones has been developed by **General Electric's Missile and Space Vehicle Department.**

GE scientists said the new ablative material can be produced for much less cost than the phenolic materials currently in use. Space flight tests are expected to be conducted within a few months.

Dr. Leo Steg, manager of the company's aerosciences laboratory, reported recently that time as well as money could be saved in producing epoxy. Phenolic materials are either laminated from impregnated tape or molded under high pressure. Epoxy is molded at low pressure.

Another advantage of epoxy resin, Dr. Steg said, is that it can be made elastic, flexible or hard, depending on the job to be done, and has good heat-protective qualities in all forms.

The new material has been tested successfully in a supersonic flame of more than 5000°F.

VOUGHT VOLUNTEERS FOR ARMY RESEARCH

Army equipment once ran mostly to brass, steel and leather. Today's soldier needs are not so simple.

Miniaturized electronics. Nuclear power. Super alloys. Advanced optics. The Army is striving to make this standard equipment for today's soldier-specialists. The modern Army is making headlong advances in new arms and techniques. It's a fluid research front, familiar to Chance Vought's weapon specialists. They have volunteered their experience to Army researchers.

Vought is a "regular" in weapons development. Every year since 1919, the U.S. Military has been equipped with at least one Vought weapon. To its capabilities in manned aircraft, missiles and electronics, the company recently added contract responsibility for integration of NASA's "Scout" space research rocket.

Vought has pioneered and delivered the most advanced weapons. Accompanied by support equipment, indoctrination specialists and fast-acting Field Service, these weapons were *effective systems* immediately on receipt. This experience is being offered the Army in several new research areas.

Battlefield weapons, along with anti-submarine warfare, missile and piloted aircraft developments, are specialties in Vought's Aeronautics Division. Other major interests are being aggressively advanced in the company's Astronautics, Electronics, Research, and Range Systems Divisions.

CHANCE VOUGHT
DALLAS, TEXAS

DEFENSE ON THE DOUBLE

"How fast will it move?" This is one of the questions the modern U. S. Army asks first about new equipment. This is critical in the swift Army units that constantly train themselves to move even faster. Speed is the modern U. S. soldier's equalizer. It helps him overcome great distances in his world-wide watch over potential trouble areas. It can help him offset an aggressor's advantage in numbers. Equipment that can accompany, arm and sustain this fighting man anywhere on the globe is essential. In trained Army hands it will mean defense on the double – any time, any place!

CHANCE VOUGHT
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AERONAUTICS · ASTRONAUTICS · ELECTRONICS · GENESYS CORP · RANGE SYSTEMS · RESEARCH

Videotape Successfully Used To Record Radar Signals

Signal Missile Support Agency finds great advantage in immediate playback capability for trajectory evaluation

WHITE SANDS MISSILE RANGE, N.M.—The first successful use of Videotape for recording missile tracking radar signals recently was announced here by the U.S. Army. Inputs have been recorded from the screens at all five radar stations which are strung out over a 4000 sq. mile area.

The tape and recorder were originally developed by **Ampex Corporation** to record video and audio signals. Because the Videotape has a video response uniform within ± 3 db from 15 kc to 2.5 mc, it was found that it could be employed to record radar signals following their conversion through a radio receiver to a somewhat lower frequency.

The converted signals are still too high for most standard recorders, but the amount of conversion that can be accomplished accurately is limited.

ANTENNA for new AN/FPS-16 instrumentation radar units at White Sands. It is considered the first radar designed originally for supersonic missile tracking.

Hundreds of missile firings reportedly have been recorded by the Army's Signal Missile Support Agency. The technique is considered a significant advance because it permits immediate playback of recordings. Portions of the trajectory of a missile may be restudied without the need for screening many thousands of feet of film from standard optical systems as was previously necessary.

- **System description**—The recording of the radar signals is done in successive narrow, vertical bands on the Videotape by four small video heads which have a minimum life of 100 hours of recording time with normal routine maintenance. Sound, or audio recording, can be captured longitudinally along one edge of the tape.

The White Sands recorder has two audio channels. One channel records sounds of the blast-off. Another audio channel, added by Signal Agency engineers, is being used as a "cue" channel. This channel makes it possible to put an audio pulse on the tape at any point to identify certain portions of the radar data recording for special study.

(At White Sands the recorder operator puts a pulse on the "cue" channel to designate the tape footage of flight data especially important in evaluation. When the tape is reproduced, this pulse produces an audio tone through the "cue" head to indicate the portion of tape to be evaluated.)

Simultaneously with the video and

audio recording, a control track is recorded longitudinally along the opposite edge of the tape. This control track provides for perfect synchronization of tape and recording heads.

The system, comprised of electronics and a tape transport, fits into one double electronics rack and one console and requires less than 100 square feet of floor space. Providing a complete recording and reproduction system, the machine achieves up to 64 minutes of recording time (when using 12.5 reels).

Tape motion and modes of operation are controlled at the right-hand control panel on the console, or at a remote control unit. System operation may be monitored by means of indicators located on the control panel.

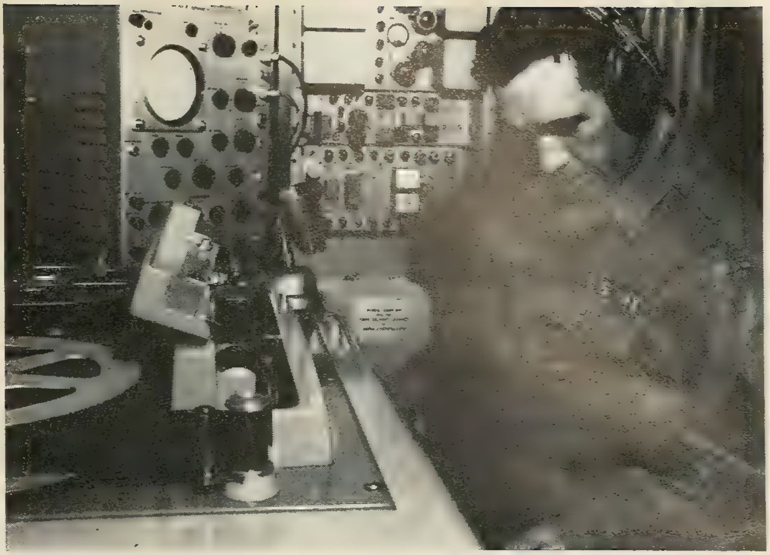
- **Recording techniques**—The converted radar signal modulates a high-frequency carrier. This frequency-modulated signal is amplified and then impressed on the video heads. A modulator circuit is in operation during the record mode. A demodulator circuit is in operation during the reproduce mode.

This modulator/demodulator circuitry serves the dual purpose of producing the frequency modulated signal during the recording process, and of recovering the original video signal by demodulation during the reproduction process.

- **Unique design**—To provide over an hour of recording time, Ampex developed a special helical method of recording which permits the video information to be packed on the tape in tight, vertical tracks. Even though basic recording principles lend themselves admirably to Videotape television recording, the video signal presents a space problem. Containing frequency components in a range which approaches direct current at the low end and extends to over 4 mc at the upper end, the video signal requires more tape area than does the audio spectrum.

For example, a conventional audio recorder, operating at a tape speed of 7½ ips, records a 15 kc signal at a rate of 2 kc per inch of tape; thus, the wavelength of that signal as it appears on the tape is ½ millimeter. To record a 4 mc signal so that its wavelength on the tape would be ½ millimeter (assuming the use of the same type head) would require a tape speed of 2000 ips—well over 110 miles per hour.

Obviously, to provide an hour of Videotape television recording with this method would require a reel of gigantic proportions. A study revealed that the use of very precise heads—incapable of being produced in quantity—could result in the required tape speed being reduced to approximately 200 ips, but a reel-to-reel tape speed of this magnitude still proved too high for a practical machine, as it resulted in a playing time (using reels of tape of a reasonable size) far too short to allow necessary recording time for test operations.


VIDEO RECORDER is operated by Sgt. 1/C R. F. Perkins, radar technician, as it follows the flight path of a missile fired at the White Sands desert installation.

To solve the problem, a special revolving head assembly capable of helical recording was developed. The 2-inch wide magnetic tape, moving at only 15 ips, curves past a rotating disc with 4 equally spaced magnetic heads. Despite the seemingly slow speed of the tape, information is packed rapidly onto the magnetic tape, for each head—in turn—records successive narrow, vertical bands of video information.

Speed of the head assembly is 14,400 rpm. In this way, a head-to-tape velocity approaching 1500 ips is attained. Simultaneously with the helical recording of the video information, stationary heads record the audio tracks and a control track in a linear manner along the opposite edges of the tape.

Despite the electronic complexity of this uniquely designed head assembly, it presents no human engineering problems, according to Ampex. Specialized employees are not required to operate the recorder, for it operates about the same as most voice recorders, the company said. Other applications—Videotape recorders also have been used for static test firings and other hazardous operations. Cameras are placed in the static test stands that are used to evaluate missile motors, and the recordings are made of flame characteristics and acoustic factors. Mounting the cameras in climatic and environmental chambers, the reaction of missile components to extreme degrees of temperature and humidity is captured and preserved for study. The recordings are made from television cameras placed in shock and vibration-proof testing equipment.

- **Future uses**—Two additional uses are planned at White Sands for Videotape recording.

Work is presently underway to install television cameras in impact areas. From these strategic spots, it is believed the recorder will capture information of the final phases of the missile's trajectory.

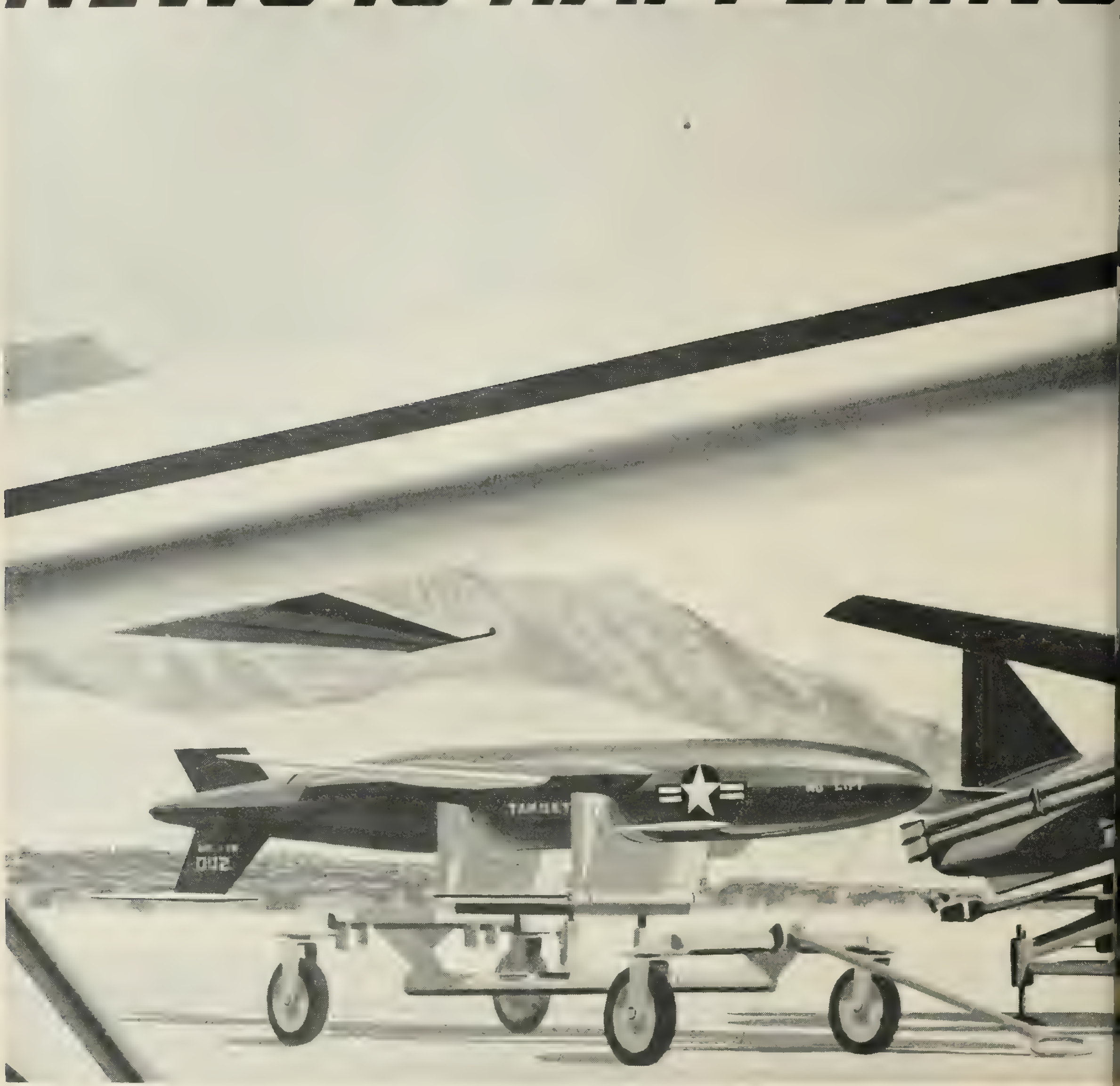
It may also be used to train radar operators. Through reproduction on an oscilloscope of the Videotape, trainee operators will be schooled in what they can expect when they first man an oscilloscope for radar tracking of a missile. Tapes will also be used for operator critiques.

New Tracking Beacon Weighs Under 10 Pounds

SCHENECTADY, N.Y.—A tiny transistorized radar beacon for missile and satellite tracking has been developed by **General Electric.**

The C-band unit weighs less than ten pounds, occupies only 70 cubic inches, and is capable of 400 watts output. GE engineers say it is the lightest and cheapest device of its type and power yet produced.

NEWS IS HAPPENIN



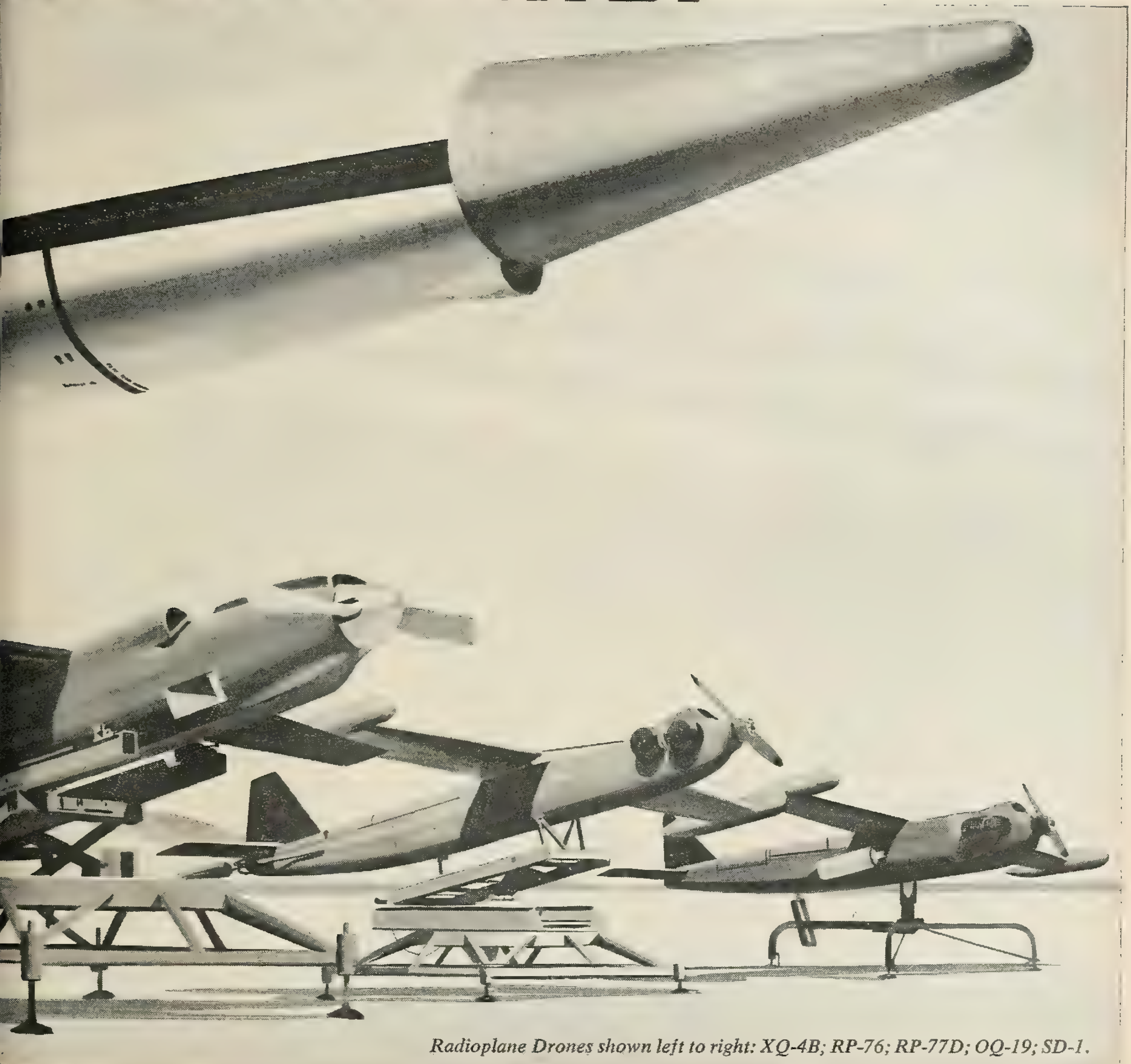
RADIOPLANE CREATES FIRST FAMILY OF UNMANNED AIRCRAFT TO TRAI MEN, EVALUATE WEAPON SYSTEMS, AND SURVEY ENEMY TERRITOR

Radioplane produces an entire family of multi-purpose drones that fly by remote control. As targets, drones perform as aircraft, then are recovered by parachute for re-use. As evaluators, drones simulate the action of enemy aircraft while they score our weapon systems' effectiveness. On surveillance missions, drones fly cameras, take photos, return with information within minutes.

For 20 years, Radioplane has been the leading producer c drones. Radioplane's leadership in the field typifies the year ahead thinking of Northrop Corporation and all of its Divisior The Corporation's continuing goal: design concepts for tomc row, hardware for today – developed, produced, and delivere on time – and at minimum cost.

NORTHROP
CORPORATION Beverly Hills, California

AT NORTHROP



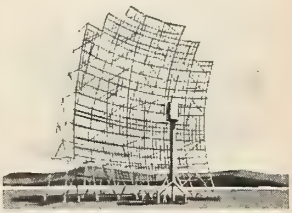
Radioplane Drones shown left to right: XQ-4B; RP-76; RP-77D; OQ-19; SD-1.

NEWS FROM OTHER MEMBERS OF THE NORTHROP FAMILY

NORAIR designs and builds complete weapon systems, missiles, airframes, related products. In production: Snark SM-62 and the first low-cost twin-jet trainer for America's airmen–the T-38 Talon.

NORTRONICS makes news with America's 2 most advanced inertial and astronertial guidance systems – LINS and A-5 – is also a leader in automatic test equipment and mechanical ground support.

INTERNATIONAL, Division for foreign operations, is now introducing the supersonic N-156F Freedom Fighter to provide our allies with maximum combat effectiveness – at minimum cost.



PAGE Communications Engineers, builders of strategic global networks, has been selected by USAF to link England-Spain-Morocco with troposcatter, telephone, teleprinter and data communications.

British Astronautics

- ***Double Spectre rocket engine used to power Blue Steel***
- ***Further spending proposed for Australia's Woomera Range***
- ***Largest U.K. aviation firm sets up advanced projects group***

by G. V. E. Thompson

London—It has now been announced that the **de Havilland** Double Spectre rocket engine D. Spe. D 1 (M/R, Aug. 24) is being used to power the stand-off bomb *Blue Steel* developed by **A. V. Roe.** Double Spectre consists of a variable-thrust Spectre 5 engine mounted beneath a fixed-thrust Spectre 4, both running on kerosine and high test peroxide. The thrust of the combined engine can be varied between 800 and 16,000 lb.

Static tests of the Double Spectre engine mounted in *Blue Steel* have been made at de Havilland's test site at Hatfield, Hartfordshire. Environmental tests of the missile have been carried out at the Weapons Research Establishment, Salisbury, Australia.

• **Further development of Woomera**—WRE, Salisbury (near Adelaide) is the headquarters establishment for the joint U.K./Australia missile testing project. It is 320 miles from its better-known outstation at Woomera, which is the launching base stretching 1300 miles to Broome, on the north-west coast. This is the longest overland testing range outside Russia.

The establishments have been constructed, equipped and staffed by Australia, and so far over £200 million have been spent on the project. The range has been used for testing the Australian-designed rockets *Malkara, Long Tom* and *Aeolus,* but the majority of the missiles fired have been developed in the United Kingdom.

A frequent courier service of Comet 2 aircraft carries Ministry of Supply or contractors' staff between the United Kingdom and Edinburgh airfield (near Salisbury) or the airfield 25 miles from the Woomera rangehead. Airstrips have also been built at Evetts Field, on the range itself, and are used for launching Meteor, Jindivik and Canberra pilotless target aircraft.

Prototypes, guided missiles and research vehicles are assembled at Salisbury from components and sub-assemblies flown out from Britain. Pre-flight inspection and tests are made both at Salisbury and at Woomera. The headquarters establishment includes a comprehensive group of workshops and research laboratories, with facilities for carrying out environmental tests, investigating defects, and analysing data obtained in the trials. The range itself is provided with every modern instrument for obtaining records of the behavior and performance of the missiles during flight trials.

The weapons which have been tested on the range include the **Bristol-Ferranti** *Bloodhound,* the **English Electric** *Thunderbird,* **de Havilland's** *Firestreak,* the **Fairey** *Fireflash,* **Armstrong Whitworth's** *Seaslug,* and the Australian *Malkara.* Three firings of the **Saunders-Roe** *Black Knight* rocket have taken place this year; on the third flight a maximum height of 500 miles was attained, the horizontal range being 75 miles. In addition Woomera has been used for upper atmosphere research, including work with in connection with the IGY. For this purpose, *Skylark* rockets have been used.

Other research activities include unmanned balloon flights to over 100,000 ft. to record cosmic rays, and supersonic aerodynamic studies.

It is now proposed to spend another $150 million on the programme. This will be used to develop further facilities. Woomera is likely to become the base for the British spaceflight programme. There are reports that the U.S. may also use the range, and possibly even launch a manned satellite from Woomera.

• **Progress with** *Blue Streak*—Nearly £3 million has recently been spent in extending the range into Western Australia. Meanwhile large concrete underground launchers are being constructed in cliffs 30 miles west of Woomera. These are intended for the British long-range ballistic missile *Blue Streak.*

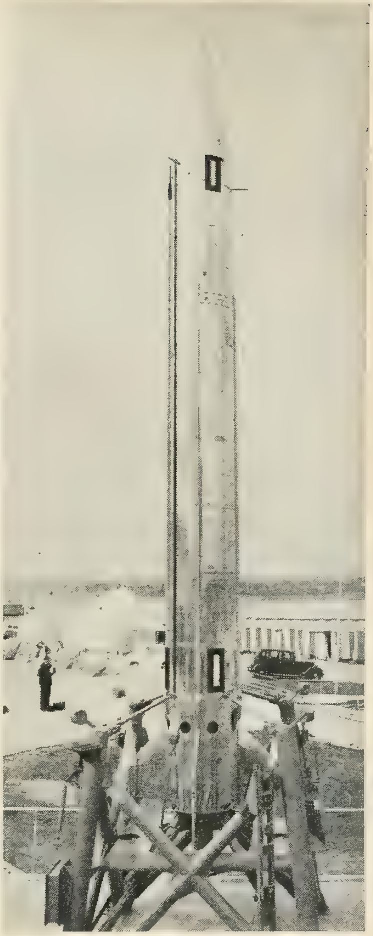
Ballistic tests on *Blue Streak* will soon be held at Woomera. The stated range of the missile is 2875 miles, or over twice the length of the range, so that eventually it will travel out over the Indian Ocean. The weapons to be used in the present series of tests will not carry explosives; in service, they will be fitted with thermonuclear warheads.

Blue Streak is intended to be the principal weapon in the British armoury, and has been designed to satisfy the requirements arising from Britain's geographical position. The prime contractor is **de Havilland Propellers Ltd.** No design information has yet been released, although the public can see the complete airframe (manufactured by **de Havilland Aircraft Co.**) in test towers at Hatfield.

The missile appears to be about 75 ft. high by 10 ft. diameter, and made from thin stainless steel stiffened by axial corrugations. It is a single-stage vehicle propelled by two kerosine/-LOX engines built by **Rolls-Royce** to modified **Rocketdyne** designs. Tests on the engines themselves at Spadeadam, Cumberland, have now been followed by static and strength tests on the assembled vehicle at Hatfield. Guidance is by the Sperry Gyroscope Co. Several designs for satellite and space-research vehicles utilising *Blue Streak* as a first stage have been drawn up by de Havilland and were discussed at the Commonwealth Spaceflight Symposium.

• **Hawker Siddeley establish astronautics group**—The largest aviation organization in Britain, **Hawker Siddeley,** has just set up an Advanced Projects Group, which will work on various aspects of astronautics and on supersonic transports. The Group will be located at Kingston-upon-Thames, Surrey. Initially, it has been formed by drawing some of the senior personnel from within the other members of the organization: **Hawker Aircraft,** A. V. Roe, Armstrong Whitworth, etc., but additional staff are now being recruited.

British Missiles At Farnborough Show



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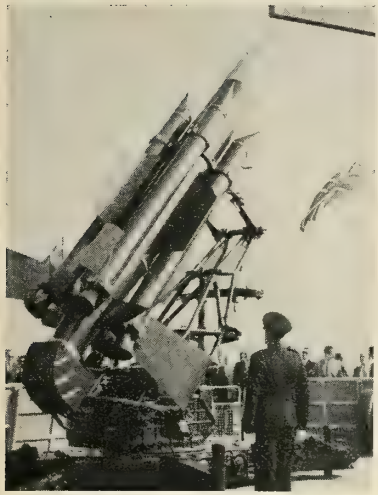
MINISTRY OF SUPPLY's two-stage research vehicle *Black Knight* was on public display for first time. Nose section of an experimental head that re-entered atmosphere from height of 500 miles and 12,000 fps was also demonstrated.



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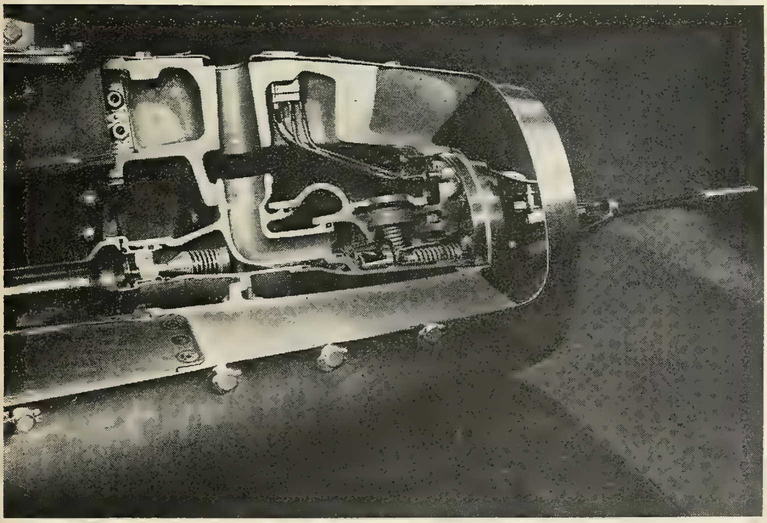
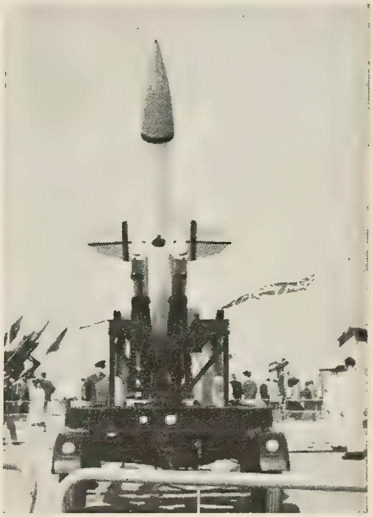
BRITISH Army now has first units of English Electric's solid-propelled *Thunderbird.* Improved version is in development stage and firm is working on solid-propellant tactical missile.



FOR FIRST TIME, cutaway ramjet—Bristol Siddeley's Thor BT-1—was demonstrated. Powerplant for early version of *Bloodhound,* the ramjet has a centerbody-type intake. Nose cone projects forward of the intake lip to focus the shock waves. A secondary shock wave occurs in the annular duct between the lip and centerbody island.



HIGHLIGHT OF SBAC display was helicopter-lifting of Bristol/Ferranti *Bloodhound* and trolley weighing some two tons. U.K. intends to keep surface-to-air-missile developments in the same family.

Mail By Rocket Over North Sea

from an M/R Correspondent

CUXHAVEN, WEST GERMANY—Rockets are carrying mail regularly across the North Sea.

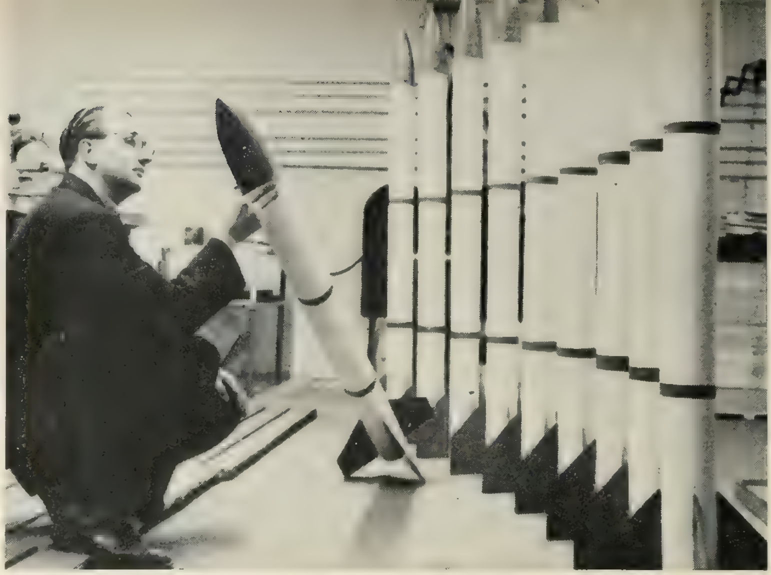
The German Rocket Society has begun mass production of mail-carrying rockets, it reported last week at its eighth national convention in this seaport city. The first 10 were fired successfully and landed by parachute on islands off the coast.

The German society, which helped in the early 1930's to open the way to space, recently increased its activity with a series of projects emphasizing peaceful uses of rockets.

Late this year, the society will introduce an oil-spraying rocket that will be used to facilitate shipwreck rescue operations off the German coast.

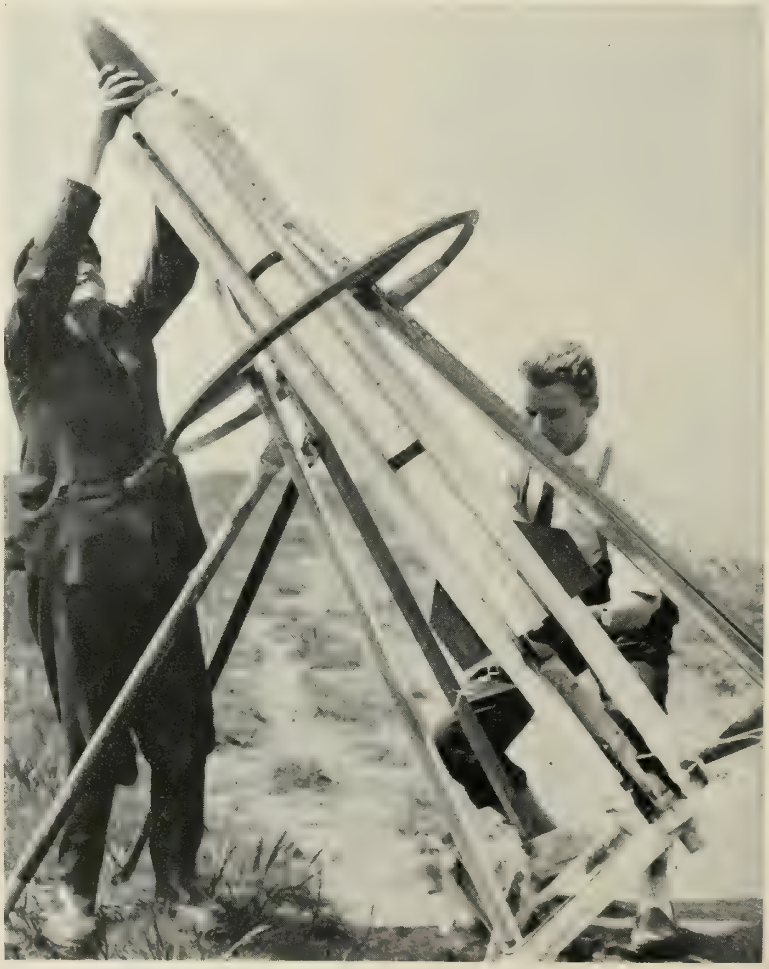
The rocket is fired like a crossbow from the launcher shown below. A shield protects the archer from exhaust gases. Inclined stabilizing fins make the rocket spin around its longitudinal axis. Two little holes open in its "warhead" immediately after blastoff and the centrifugal force propels a quart of oil over a great distance.

Though the rocket flies only 900 feet, it can spray a thin oil film over an area of about 90,000 feet and rough waves will be calmed immediately. It is believed that the oil-spraying rocket also could help seafaring airplanes and helicopters land on rough sea.



THESE TEN mail-carrying rockets already have been fired successfully across the North Sea. The German Rocket Society has begun mass production of the proven model.

OIL-SPRAYING rocket is fired from this launcher. Shield protects archer.



ROCKET BUFFS ready the postal rocket for firing. It will deliver postcards and letters to North Sea islands where it will land by parachute and be returned.

System May Bring Circular Orbits

General Electric's 'GESOC' method of control is designed to correct elliptical orbits at apogee using infrared horizon sensors

PHILADELPHIA—The conventional elliptical orbit of a satellite may be circularized by a new method developed by **General Electric** engineers here. The system, called GESOC—General Electric Satellite Orbit Control—is made up of two basic elements: a computer and a small solid-rocket gas generator. Scheduled for early flight test, GESOC uses an infrared sensor to determine orbit parameters. The transistorized analog-digital-analog computer weighs 2½ pounds.

Circular, or low-eccentricity, orbits are desirable for many of the application satellites being designed—such as mapping, photography, and fixed-range communication vehicles. This circular orbit, however, is practically impossible to achieve with present launching techniques. The satellite must be put into an elliptical orbit which is then modified to a circle. This is accomplished by the computer, which measures and calculates the exact original orbit and compares this with the desired orbit. The computer then commands the gas generator to fire the proper nozzle to inject the vehicle into the new orbit.

The control system has a cluster of four nozzles positioned in opposite directions. The generator supplies gas to any number of the nozzles as commanded by the computer. Nozzle control is possible down to intervals of 300 microseconds.

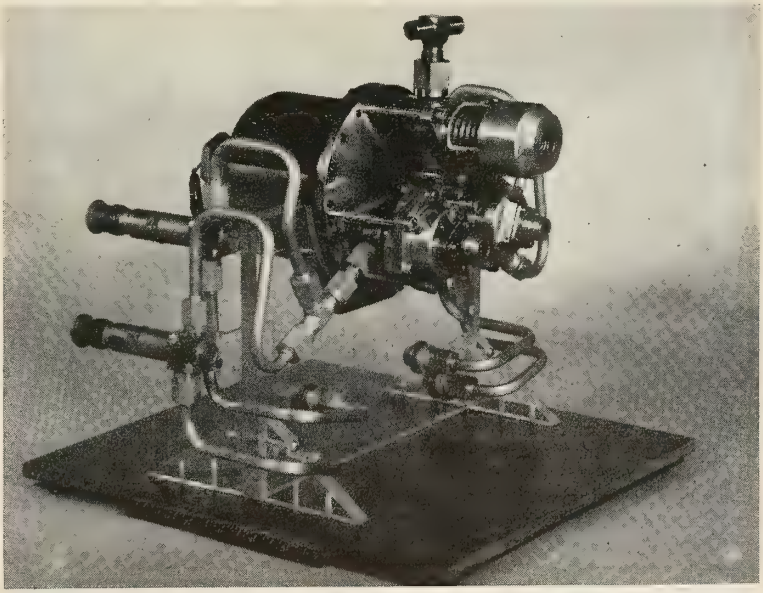
In the case of an elliptical orbit with an apogee and perigee of 600 and 200 nautical miles, for example, the magnitude of the velocity vector may be increased by 520 ft./sec. at apogee and the orbit will become circular. GESOC can compute the necessary impulse and initiate the correction by firing a solid or liquid-fueled reaction thrust system at the proper point on the orbit.

The vehicle must be attitude-controlled. However, the required stabilization is achieved by the same equipment which provides the intelligence for the computer. This is one of the major advantages of the apogee method of orbit transfer. The use of such a satellite orbit control system is a way of compensating for inaccuracies arising from error tolerances on the launching vehicle guidance and control system.

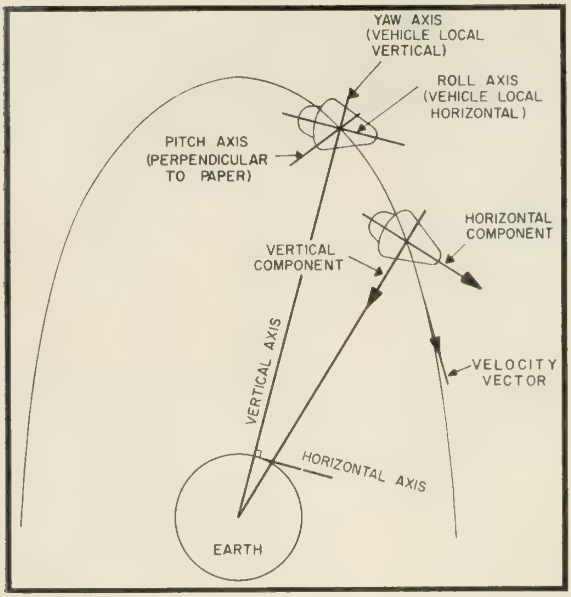
- **Choice of sensing systems**—The vehicles for which the GESOC computer is designed are attitude-stabilized around their pitch and roll axes by an IR horizon sensor system. The third (yaw) axis can be stabilized by a number of different sensing systems such as a magnetic aspect sensor, which makes use of the earth's magnetic field to sense yaw motion, or a pitch rate system. This stabilization keeps the vehicle oriented in such a way that its axes are fixed relative to the earth. The yaw axis of the vehicle is coincident with the vertical axis of the earth; therefore, the roll and pitch axes of the vehicle are in a plane perpendicular to the vertical axis passing through the center of the earth (assuming that the earth is a perfect sphere).

In order that a vehicle be travelling a circular orbit, the magnitude and angle of its velocity must satisfy the definition of such an orbit at the given altitude. For a circular orbit, the velocity of the vehicle varies inversely with the square root of the distance from the earth's center. If the earth is assumed to be spherical, the angle which the velocity vector makes with the horizontal axis of the attitude-stabilized satellite is always zero. A vehicle in an elliptical orbit is specified by a velocity vector which has horizontal and vertical components along the local axes of the vehicle.

For the attitude-stabilized vehicle


GESOC system consists of 2½-pound transistorized analog-digital-analog computer and a small solid-rocket gas generator which supplies fuel at computer's command.

corrections at apogee only . . .



IN ELLIPTICAL orbit, the velocity vector makes a zero angle with orbit path at apogee and perigee.

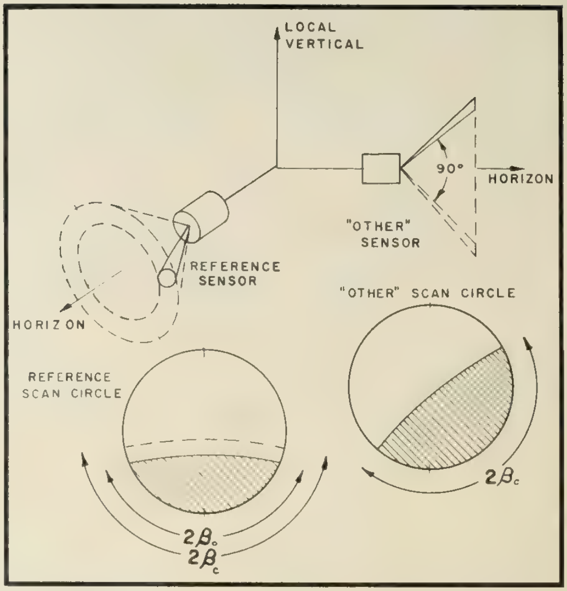


DIAGRAM shows how GESOC's two infrared sensors are mounted perpendicular to each other.

discussed, these components are also defined by the earth's coordinate system. The magnitude of the velocity vector is a function of the altitude at apogee, perigee, and the given point on the orbit.

• **Simplified computer**—To circularize an elliptical orbit, the vertical component of the velocity vector must be removed and the horizontal component altered in such a way that it is equivalent to the magnitude of the velocity vector of a circular orbit at the given altitude. The magnitude and angle of the correction impulse are specified by these conditions.

At apogee and perigee of an elliptical orbit, the angle which the velocity vector makes with the orbit path is zero. Therefore, only the horizontal component of the correction impulse is necessary to circularize the orbit. Because of this and other considerations, the GESOC correction computer is greatly simplified since it is designed to correct orbits only at apogee. However, this is no limitation because any desired orbit can be obtained if the proper transfer orbit is utilized. This, of course, involves two corrections.

The necessary inputs to the computer or calculation of the correction impulse are altitude measurements. For a correction computer that can correct an orbit at apogee only two altitude readings—those at the apsides—are necessary to calculate the velocity impulse needed to circularize the orbit.

An infrared horizon sensor system provides altitude information for GESOC. The primary use of this system is attitude stabilization, but it has been adapted to yield altitude information.

• **Hot earth, cold sky**—The IR horizon sensors make use of the fact that the earth is relatively "hot" (250°K) while the sky is "cold" (about 5°K). Their voltage output is inversely proportional to the amount of infrared radiation falling on the detectors and thus, to the relative amounts of sky and earth which they "see".

The GESOC system contains two infrared sensors mounted perpendicular to each other, as shown in the diagram. The cone angle of the scan is 90 degrees, and is referenced at 180-degree intervals. If one sensor is taken as the reference, its output is a voltage pulse proportional to the amount of scan that intersects earth.

In the vehicle for which GESOC is designed, the reference scan axis of the horizon sensor system coincides with the horizontal axis of the vehicle. The second, or "other," sensor measures the attitude error. This is the angle between the vehicle local horizontal and the reference sensor scan axes. This information is provided by a phase-shift detection in the "other" sensor.

The first circle in the diagram represents the scan from the reference sensor. The shaded area is the amount of earth which the sensor sees. This information is measured as pulse width data. The "other" scan is shown in the second circle. For the application taken, the "other" scan axis is oriented along the vehicle pitch axis. If there were no tilt about either axis, these two scans would be identical.

• **Advantages of GESOC**—There are several advantages in the apogee correction technique for which GESOC is designed:

1) Minimum energy is required in making the correction since the thrust is applied parallel to the original satellite vector velocity.

2) Direction of thrust is horizontal. This simplifies orbit control computation to that of velocity change only.

3) Orbit parameters have minimum time variation at apogee and perigee. This decreases the effect of finite propellant burning time and errors due to initiating thrust before or after apogee or perigee is reached. (This characteristic, however, may also be a disadvantage.)

With this system, there are only two possible altitudes for a circular orbit from a given ellipse. If neither apogee or perigee are at the desired new orbit altitude, then a transfer orbit is necessary. Also, it is difficult to distinguish exactly where apogee and perigee are, since the rate of change around these points is very small, especially for low-eccentricity orbits.

No Future for Solids in Space Ships

American Chemical Society hears that solids lack momentum needed for large vehicles. Convention also views advances in plastics, elastomers and polyurethanes

by John F. Judge

ATLANTIC CITY, N.J.—Solid propellants are out of the space flight picture. According to Dr. Lloyd A. Wood, chief of the research grants and contracts division of NASA, there are many specialized uses for solids, particularly in small rockets, but the larger vehicles will depend on other means for space propulsion.

Speaking before the Gas and Fuel Chemistry Division at the American Chemical Society's 136th Annual Meeting, Dr. Wood explained that in such systems it is the momentum that counts. What is needed is maximum momentum per unit mass of fuel, and in this respect, solids are not the answer.

Dr. Wood also said space technology will have little effect on everyday life until men can project great masses into space. This will require some dramatic developments in propulsion methods.

Until this occurs, the activity in space can best be described as intellectual effort, resulting mainly in accumulation of knowledge in communications, navigation, weather and scientific matters.

• **Plastic nozzles**—Results of a series of tests by George Epstein and Harry King of **Aerojet-General** show that plastics may find use in the toughest position in rocketry—the nozzle.

The heat-resistant types of plastics reveal promise with phenolic and phenolic-silicone compounds lasting longest at a 5400°F temperature.

A reinforcing material known as Refrasil, cut in half-inch squares and positioned at right angles to the blast, provided the best results.

The two scientists told the Division of Paint, Plastics and Printing Ink chemistry that the properties of the phenolic-Refrasil nozzles may be improved greatly by increasing molding pressure in fabrication. The tests were part of a program initiated to establish materials, processes and design criteria to provide lighter weight nozzles that are dimensionally stable under firing conditions.

Aerojet-General's Robert F. Chaiken, speaking on the role of binders in composite solid propellants, said that the importance of the oxidizer monopropellant layer and the decomposition characteristics of the solid oxidizer and binder have been largely ignored by many contemporary investigators. If the burning propellant surface is pictured to consist of individual oxidizer particles which can decompose in their own individual flame zones, then the binder's task can be considered to manifest itself as a perturbation of the monopropellant thermal layer surrounding the decomposing oxidizer particles.

Depending on the decomposition characteristics of the binder used, the effects of the binder on the burning rates can be shown.

• **Mixing checks**—The detection of nonuniformity in propellants during mixing by radioactive tracer techniques was explained by A. M. Hoffman of Aerojet-General. Reliable methods have been developed in pilot plant and production scales. A composite propellant, before casting, is a slurry containing finely divided crystalline solids consisting of oxidizer and additives in the binder. Reproducible ballistic performance and curing properties are dependent upon the uniform dispersion of these additives.

Hoffman said that the results of tests with curing agent and burning rate modifier showed that regardless of the size of the mixer, the materials were incorporated into the slurry in 15 to 20 minutes.

Walter C. Hourt of **Atlantic Research Corp.** said that there is need for definition of the chemical structure of plastics in relation to mechanisms of carbonization and the thermo-chemical properties of reinforcements to ensure continued development of plastic heat insulators for solid motors.

A theoretical evaluation of a model insulator indicated that char formation of highly endothermic pyrolysis and gaseous decomposition products are of primary importance to good performance.

• **Polyurethanes**—Certain basic resin parameters are superior to weight recipes in describing polyurethane propellants, said H. E. Marsh, Jr., of **Jet Propulsion Laboratory.**

Because of variations in raw materials, Marsh disclosed, the ratio of isocyanate to hydroxyl, the ratio of triol to total hydroxyl, the average molecular weight between branches and the degree of branching are all useful parameters.

The scientist stated that tensile capacity had been observed in the characteristic way that related propellant formulations trade off tensile strength with elongation over broad ranges of formulation parameters. These effects can be readily seen from a graphical comparison of tensile capacities.

• **Shear strengths**—A unique alkaline surface treatment which consistently produced tensile shear strengths in excess of 5000 psi using ¼-inch bonded overlap of a non-stainless steel alloy was developed by Aerojet-General. George Epstein and Sidney Litvak of the structural plastics division reported that the treatment was extended to other metals such as titanium, nickel, beryllium and stainless steel with considerable success.

The scientists explained that improvements in tensile shear strength of metals were also effected by the use of a vinyl-phenolic primer followed by a complete cure.

Other methods included the evacuation of entrapped air from liquid epoxy-base adhesive systems and curing under pressure for powdered epoxy-base systems.

Multi-ply metal laminated pressure cylinders are being developed and produced in quantity and their performance depends upon the quality of the adhesive bond.

Space Probes Must Be Sterilized

LONDON—Biological pollution tolerances should be kept to less than 10^8 dead organisms per probe for moon and planetary shots.

The introduction of terrestrial organisms and contaminants might so distort the biology of a planet as to constitute a scientific catastrophe, said Richard W. Davies and Marcus G. Comuntzis of **Jet Propulsion Laboratory.**

The two scientists told the 10th International Astronautics Congress that, because of the exponential growth rate of bacteria, space probes that have any possibility of extraterrestrial contact should be carefully sterilized.

A combination of ethylene oxide—carbon dioxide gases, radiation, and heat will permit the sterilization of 95% of the payload parts without seriously degrading their performance characteristics.

Elimination of substances of biological origin, such as casein glue or shellac, and the incorporation of those organo-metallic in nature might prove valuable in reducing contamination during initial stages of probe assembly.

Davies and Comuntzis said sterilization may be maintained by a protective shroud housing a disinfectant through the final countdown and initial atmospheric flight.

Although the environment of space is hostile to terrestrial organisms, the scientists said that such self-sterilizing mechanisms are not very effective. For example, ultraviolet radiation will destroy exposed organisms but its penetrating power is so low that organisms can survive if surrounded by a small number of dead ones.

The biologists also suggested the creation of an agency specially qualified to perform terminal disinfection and to ascertain the degree of sterilization necessary.

Astronauts' Eyes Could Be Damaged by Sun Rays

LONDON—The sun's bright rays in space, undiminished by earth's protective atmosphere, will make it necessary to design space ships to protect astronauts' eyes.

Dr. Hubertus Strughold, research adviser at the U.S. Air Force School of Aviation Medicine, San Antonio, Tex., and an M/R contributing editor, called attention to the problem in a paper sent to the 10th International Astronautical Congress here recently.

Solar illuminance at the earth's mean distance from the sun is about 30% higher in space than the maximum brightness at the earth's surface, Strughold reported. At the distance of Venus' orbit, this is almost doubled, while the figure for Mars' orbit is reduced by more than 55%. He gave these figures for the illuminance in lux (lumens per square meter) at the mean distances of the various planets:

Mercury	938,000
Venus	268,000
Earth	140,000
Mars	60,000
Jupiter	5200
Saturn	1500
Uranus	380
Neptune	150
Pluto	90

The maximum solar illuminance observed on earth is on the order of 100,000 lux, Strughold added. In space, the brightness of the sun-illuminated earth may be enough to cause a dazzling glare, he added.

"The direct solar rays coming out of a dark sky produce light-shadow effects in the cabin which pose problems with regard to visual adaption, and require special attention in design of windows," Strughold continued.

Looking into the sun with the naked eye may lead to retina damage even a retinal burn that would cause a blind spot. This danger increases on a trip toward the sun, such as a Venus expedition. Strughold said the danger probably disappears on an outward trip somewhere beyond Jupiter.

ASTRONAUT Lt. Malcolm Scott Carpenter, NSU, in the gondola of the human centrifuge at the U.S. Naval Air Development Center, Johnsville, Pa., in a recent space flight simulation.

Viewer To Guard Pilot's Eyes from Nuclear Blast

PITTSBURGH—Space pilots will use a viewing device, similar to conventional flight periscopes, being developed by **J. W. Fecker, Inc.**

Designed to eliminate the thermal problems posed by windshields, the instrument features a rapid closure system capable of shielding the pilot's vision in 500 microseconds or less from high intensity light flashes. This is designed to protect the pilot's eyes from the glare of a nuclear explosion.

The device will give the pilot a broad view, comparable to present wind-shields, and will conform to military weight and dimensional requirements.

The project is supported by a recently awarded Air Force contract.

Figuring Human Element Speeds Missile Progress

HUNTSVILLE, ALA.—Money is saved and delays are avoided in Army missile development by figuring in the human element early in design, scientists meeting at Redstone Arsenal have reported.

One missile expert said his firm uses men typical of those who will operate the finished weapon to try out inexpensive mock-up models during initial design, thus determining whether their final product will be compatible with the physical and mental capabilities of its crew.

death of a program . . .

Vanguard Aided Our Space Technology

The nation's first designed space vehicle was a greater success than failures indicated and its components are used in most newer spacecraft

by C. Paul Means

WASHINGTON—Amidst the relic machines that dot the final resting place of man's historic scientific successes and failures—the Smithsonian Institution—stands the last existing *Vanguard*.

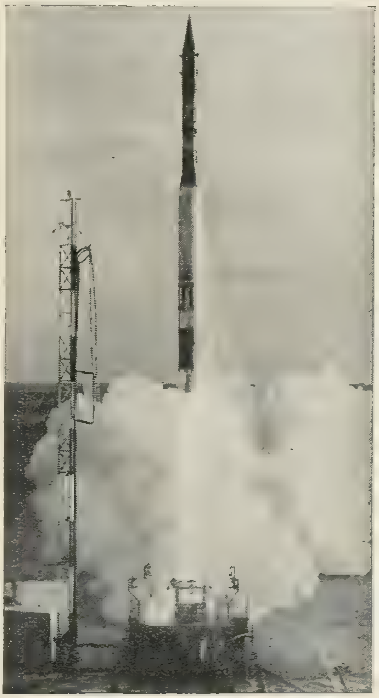
And as the nation's first rocket designed as a space vehicle leaves the scene to become a museum piece, the final assessment of its worth seems to be that the program was—in spite of its failures—a rewarding success.

Vanguard goes into the history books an enigma. In the early days, too little was given to the program and too much was asked of it. The hopeful, slightly boastful praise that met the announcement of its first launch attempt changed to derision, even ridicule, with each successive failure.

It was with a sense of relief that those connected with the program watched the last launch attempt become the program's greatest success. *Vanguard* III, after going through two days of its trying, traditional false starts last week, launched 100 pounds (50 pounds of payload) into a stable orbit. The payload, which includes various types of radiation experiments, has a perigee of 319 miles and an apogee of 2329 miles, and will map uncharted regions of space for future manned flight by detecting high-radiation pockets, temperatures, X-rays from the sun, magnetic storms and moving particles of all kinds.

The record shows that the *Vanguard* program tried to orbit satellites with four test vehicles and seven launching vehicles. It succeeded three times out of eleven. A fair estimate of the program's cost (minus the funds for the Minitrack network) is about $95 million. Each vehicle cost about $3 million, and each pound orbited cost about $1,223,000.

• **Lasting benefits**—But *Vanguard's* worth is not indicated by its batting average.



A LAUNCHING of *Vanguard*—the U.S.'s first rocket designed from the ground up as a space vehicle.

The 75 pounds that were orbited gave scientists their first insight into the true shape of the earth; allowed mapmakers to correct serious errors; and continue to give scientists a great deal of useful information about space and its properties.

Vanguard's real heritage lies in the wealth of technology obtained which will aid the designing, launching, and tracking of future space vehicles.

The program's impact has already left its stamp on present and future space vehicles. *Atlas Able, Thor Able, Scout, Thor Delta,* and *Vega* are a few of the newer space vehicles which use *Vanguard* engines, either in their original or in a modified form.

Other "fallout" benefits of the *Vanguard* program include:

- The telemetering equipment developed as part of the ground launching facilities and the worldwide Minitrack system;
- The optical equipment developed to track *Vanguard* visually;
- The technology—painfully learned—of how to build a non-missile space vehicle from the ground up, and how to design and integrate the various stages and engines;
- The indirect benefits gained from the *Vanguard* program by the ballistic missile program;
- The experience gained by many still employed in the nation's space effort.

• **Born in strife**—The decision to build *Vanguard* was made by the Department of Defense's Advisory Group on Special Capabilities four years ago. It was chosen as the best of three proposals to orbit a satellite payload during the International Geophysical year.

The losing proposals would have used existing hardware developed in the ballistic missile program. The Army's proposal, "Orbiter" was to have used the *Redstone,* and the Air Force's proposal the *Atlas.*

The decision to build *Vanguard* provoked a controversy which still rages. The Army claimed, and later proved, that their proposal could orbit a satellite before *Vanguard* could be developed.

On September 23, 1955, the **Glenn L. Martin Co.** received the prime contract from the Navy to build *Vanguard.* The Navy transferred direct control of the project to the Naval Research Laboratories, and to Dr. John Hagen. The program was transferred to the National Aeronautics and Space Administration last fall.

The *Vanguard* program did not meet its time schedule, but the vehicle was developed in the fraction of the time it takes to develop an ICBM. The program, surprisingly, met its reliability objectives.

Dr. Hagen stated before a Congressional committee that the original proposal envisaged a reliability that would give a "reasonable chance" of putting one satellite in orbit in six tries, or a reliability factor of about 15%. The program actually put 3 vehicles in orbit in 11 tries, for a reliability factor of over 36%.

The reliability of *Vanguard* has seldom been judged in comparison to the program's original objectives, or in comparison to the time and money spent on the program. The Russian orbiting of *Sputnik* brought pressure on the *Vanguard* program to achieve a rate of success that it was not capable of.

- **Learning the hard way**—A final benefit of the *Vanguard* program was that it demonstrated to the nation how a space vehicle development program should not be run.

Organizational difficulties hampered the program from the start. Project *Vanguard* became a political football in the Pentagon, with top defense leaders showing little more than apathy for the program.

According to a report by the House Appropriations Committee, "there was divided responsibility in the program to define properly the duties and authority of organization units and personnel. The Martin Co. found it difficult to get timely decisions at Cape Canaveral . . . It is the opinion of . . . those consulted at Cape Canaveral, that good 'team' effort early in the program might have reduced some of the launching delays and made it possible to expedite the test program."

The "looseness, lack of formalization, and early management problems" burdened the *Vanguard* program with a permanent liability according to the report, because the "short time scale allocated for *Vanguard*, the complex design, and the necessity for producing a relatively large number of vehicles in a short time, made it necessary to carry on many facets simultaneously and to adopt production-lines techniques . . ."

As one top rocket expert at the National Aeronautics and Space Administration put it last week, "It's a marvel *Vanguard* worked as well as it did."

CHRONOLOGY OF VANGUARD LAUNCHINGS

(TV=Test Vehicle,
SLV=Satellite Launching Vehicle)

TV-0—*December 8, 1956: Viking rocket No. 13 (no Vanguard components) launched successfully to test Cape Canaveral range facilities, tracking and telemetry systems.*

TV-1—*May 1, 1957: Viking rocket No. 14, carrying a Vanguard prototype third stage, was launched successfully for test of control system and separation, spin-up, and ignition of third stage.*

TV-2—*October 23, 1957: A complete Vanguard configuration with "live" first stage and dummy second and third stages was successfully launched for tests of aerodynamic soundness and engine gimballing.*

TV-3—*December 6, 1957: First complete three-stage Vanguard failed at lift off, preventing separation and flight test of second stage.*

TV-3 Back-up—*February 5, 1958: Complete three-stage Vanguard launched, but broke up after 60 seconds of normal flight when the control system malfunctioned. Rocket fell into the sea.*

TV-4 Vanguard I—*March 17, 1958: Successful launch of a complete three-stage Vanguard placed a 3.25-pound test satellite and the 50-pound third stage in an orbit expected to last more than 200 years. A staff report issued by Congress describes the satellite as "the most stable of any earth satellite launched to date."*

TV-5—*April 28, 1958: Last test vehicle launched with a 21½-pound instrumented satellite. First and second stages operated successfully, but a control system failure prevented activation of third stage. Rocket coasted to an altitude of 358 miles and fell to sea.*

SLV-1—*May 27, 1958: Three-stages launched successfully, but faulty second-stage burn-out threw rocket off course. Rocket flew 20 minutes to 1850 miles in space before falling.*

SLV-2—*June 26, 1958: Second stage ignited successfully but cut off prematurely, preventing achievement of orbit.*

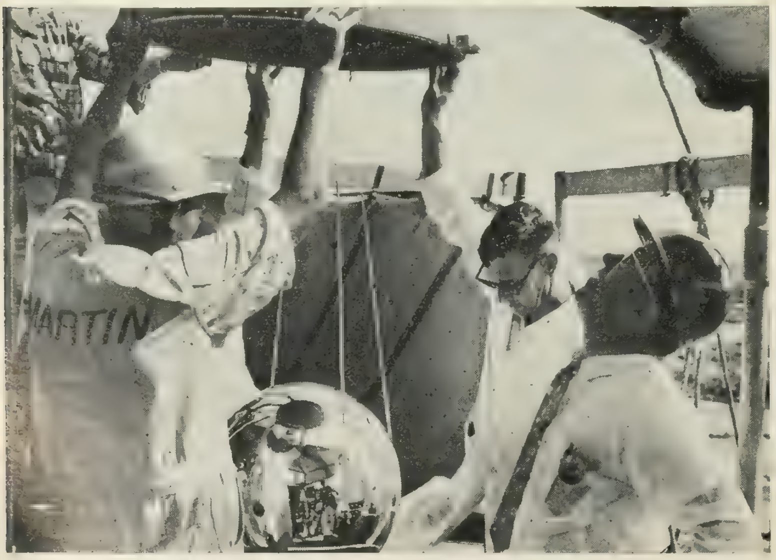
SLV-3—*September 26, 1958: Orbiting of a 20-pound satellite missed by the narrowest of margins due to failure of full second stage thrust.*

SLV-4 Vanguard II—*February 17, 1959: Successful three-stage launch placed a 23.3-pound satellite and the 50-pound third stage in an orbit now expected to last 200 years.*

SLV-5—*April 13, 1959: Launch was aborted after a malfunction in the separation of the second stage from the first stage.*

SLV-6—*June 22, 1959: Launch unsuccessful due to failure of second stage pressure regulator.*

SLV-7 Vanguard III—*September 18, 1959: 100-lb satellite in orbit.*



DIRECTOR of *Vanguard* project, both under Naval Research Lab and NASA, was Dr. John P. Hagen, here shown (at right) making a last-minute check before launching.

BEFORE-DINNER joke is shared at the M/R critique by (from left) James J. Haggerty, Jr., Fred Hunter, Clarke Newlon, Dr. Peter Castruccio, Wayne W. Parrish, Conrad H. Hoeppner, Dr. Arthur Kantrowitz, and Heyward E. Canney, Jr.

M/R Advisors Give Critique

WASHINGTON—Members of MISSILES & ROCKETS' Advisory Board and Contributing Editors met in Washington Sept. 17 to analyze the magazine's editorial content and to present their views on areas of expanded editorial coverage.

Preceding the critique, moderated by M/R Executive Editor Clarke Newlon, was the annual dinner held in their honor.

Members of the Advisory Board present were: Dr. Peter Castruccio, Director of the Astronautics Institute of the **Westinghouse Electric Corp.**; Mr. Conrad H. Hoeppner, Chief Scientist of **Radiation Inc.**; and Dr. Arthur Kantrowitz, Director of the **Avco Research Laboratory.**

Contributing Editors present were James J. Haggerty, Jr., of the Aerospace Industries Association, and Heyward E. Canney, Jr., Aeronautical Research Administrator of the National Aeronautics and Space Administration.

Members of the Advisory Board and Contributing Editors unable to attend sent critiques by mail which were discussed at the dinner.

Attending besides the M/R staff were Wayne W. Parrish, President of American Aviation Publications Inc., Leonard A. Eiserer, Executive Vice President of AAP, and Fred Hunter, Vice President and Editorial Director of AAP.

M/R staff members present besides Mr. Newlon were Publisher E. D. Muhlfeld, Managing Editor Donald E. Perry, Advertising Sales Manager W. E. Brown, Associate Editors Reed Bundy, James Baar, Charles D. LaFond, Jay Holmes, John F. Judge, C. Paul Means and William E. Howard, and Editorial Assistant David Newman.

PROBLEMS OF outer space travel are discussed by W. E. Brown, Heyward E. Canney, Jr., John F. Judge, Jay Holmes, Dr. Arthur Kantrowitz, and C. Paul Means. The dinner was held in the Cabinet Room of Washington's Sheraton Carlton Hotel.

reviews

INSTRUMENTATION FOR THE DETERMINATION OF PHASE DELAY IN A RADOME WALL; B. Carpe, Dalmo Victor Co. for WADC. Order 151549 from OTS U.S. Dept. of Commerce, Washington 25 D.C. $1.

Described is the development of an instrument suitable for accurate measurements of relative changes in electrical thickness in radomes.

Electrical thickness and effective dielectric constant are functions of the reflected phase and amplitude of a radome, according to the theory of operation that was developed. Certain inherent sources of error, effect of loss tangent, and horn requirements were established.

DEVELOPMENT OF NIOBIUM-BASE ALLOYS; Richard T. Begley. Order No. PB 151 739 from OTS, U.S. Department of Commerce, Washington 25, D.C. 192p. $3.00.

Flows and fracture studies indicate that the ductile to brittle transition of niobium is little affected by oxygen content in the range 0.01 to 0.1% O_2. Strain-hardening and strain aging in niobium were studied.

The recrystallization behavior of electron-beam melted niobium was studied in detail. Creep-rupture data were obtained on electron-beam melted niobium at (871 C) 1600 F and (982 C) 1800 F. The effect of temperature on the modulus of elasticity of niobium and tantalum was determined in the range 25C to 900C.

FUELS AND LUBRICANTS; Milosh Popovich and Carl Hering, John Wiley & Sons, New York. 312p. $8.50.

Presented is a survey of fuels and lubricants written primarily as a college text but applicable to industry as well.

Emphasis is on the correlation between the properties of fuels and lubricants and their performance in an engine or machine, and on the significance of the standard tests that are conducted on these materials.

Along with detailed coverage of the fuels and lubricants obtained from petroleum and common solid and gaseous fuels, the book includes a survey of synthetic lubricants, rocket propellants, and nuclear fuels.

A chapter is devoted to an outline of organic chemistry. The refining of petroleum and other manufacturing processes are described briefly to show their influence on the properties of the products. High energy fuels and rocket propellants are discussed generally.

INVESTIGATION OF HIGH TEMPERATURE RESISTANT MATERIALS; J. D. Walton, N. E. Poulos, and C. R. Mason. Order PB139926 from Library of Congress, Photo Duplication Service, Publications Board Project, Washington 25, D.C. 213p. Microfilm, $9.60; photocopy, $33.30.

Molybdenum-sheet substrates, 1/16" thick, were coated with aluminum, gold, nickel, platinum, rhodium and silicon, respectively, as single films by evaporation, sputtering or electroplating.

In general, film thicknesses were 0.000015 to 0.000025". A mixture of 3.5 parts of four parts aluminum and one part vanadium pentoxide with three parts silica gave a desirably rapid and high temperature reaction, producing fused coats.

DESIGN AND DEVELOPMENT OF REFRACTORY CERAMIC LINING FOR COMBUSTION CHAMBER OF UNCOOLED ROCKET MOTOR; Dwight G. Bennet and Robert F. Kimpel. Order PB 140004 from Library of Congress, Photo Duplication Service, Publications Board Project, Washington 25, D.C. Microfilm, $2.40, Photocopy, $3.30.

Zirconia, through the design of a thermal shock-resistant ZrO_2 tile, may possibly be used for a segmented rocket-engine combustion-chamber liner. Zirconia has high insulating value but poor thermal shock resistance.

STEADY-STATE PROPERTIES OF A SIMPLIFIED MODEL OF SOLID-PROPELLANT BURNING; Leon Green Jr. Order No. PB 140 356 from Library of Congress, Photo Duplication Service, Publications Board Project, Washington 25, D.C. Microfilm, $2.70, Photocopy, $4.80.

A model of solid-propellant burning is postulated, in which the complex chemical-reaction and heat-conduction problem in the gas phase is replaced by a simplified boundary condition which assumes convective heat transfer to the surface from a parallel flow of gas at flame temperature.

The effective heat-transfer coefficient is assumed to be an inverse function of propellant burning rate, which in turn is assumed to be an Arrhenius function of the surface temperature.

The model permits calculation of steady-state surface temperatures, burning rates, and temperature gradients which show the proper qualitative dependence upon the propellant and gas-flow parameters which, for the assumed values of these parameters, appear to be of the proper order of magnitude.

NOTCH SENSITIVITY OF HEAT-RESISTANT ALLOYS AT ELEVATED TEMPERATURES. PART I. PRELIMINARY STUDIES OF THE INFLUENCE OF RELAXATION AND METALLURGICAL VARIABLES; Howard A. Voorhees and James W. Freeman. Order No. PB 140 005 from Library of Congress, Photo Duplication Service, Publications Board Project, Washington 25, D.C. 111p. Microfilm, $6.00, Photocopy, $18.30.

Additional data for three alloys with conventional heat treatments: S-816 at 1350°F, Waspaloy at 1500°F, Inconel X-550 at 1350°.

Test results included stress-rupture time properties, short-time tensile properties and creep properties when stresses were changed from one level to another during a test. Cold working had the greatest effect on notch sensitivity of the several conditions investigated, but no severe case of notch weakening was observed for either S-816 at 1350°F.

missile business . . .

By WILLIAM E. HOWARD

In the windup scramble to avoid Khrushchev, Congress left withering on the legislative vine a bill of considerable importance to missile/space R&D contractors. It was HR 5326, introduced by Rep. Richard M. Simpson (R-Pa.), to extend for four more years the Office of Civil Defense Mobilization's rapid tax amortization program. Failure to act on the measure—it never got out of the House Ways & Means Committee—means all fast tax write-off certification will end on Dec. 31.

We hear an attempt to revive the program . . . will be made in January when Congress reconvenes. However, the chances that it will succeed do not look very promising. The Eisenhower Administration has apparently decided against supporting such a step—even though NASA and DOD are definitely in favor of it (M/R April 20, p. 19). Even if Khrushchev's disarmament proposals have no effect on the Defense Department budget for FY 1961, there will be no great pressure to give industry a tax break.

Undoubtedly the recent Hébert Committee investigation and the revival of General Accounting Office charges of excess profits being made by defense contractors influenced the Administration decision against continuing the program. It certainly would not have been the politic thing to do at the time.

Come January, the defense industry again can expect . . . some sharp criticism from Capitol Hill. The Hébert Committee is expected to report on its preliminary findings and then continue the investigation of company practices in hiring retired military officers. So the climate isn't likely to improve.

Since June, 1958, the rapid amortization program . . . has allowed many companies to write off 50-75% of the cost of expensive, specialized R&D equipment in five years, instead of the normal 20 to 40 years. This practice has helped the cash position of firms obtaining certification—allowing them more funds to plough back into basic research of their own and to assume the financial risks involved in taking on big DOD and NASA R&D programs.

The Treasury doesn't lose any money. It gets it in the long run. But many experts believe that the country will be the loser if curtailment of this tax benefit results in a cutback in basic research. This is the point that gets obscured by political considerations.

About the only chance to get this point across . . . will come on Dec. 3, when the House Ways & Means Committee holds a hearing on R&D expenditures in connection with a general tax reform bill. Only two industry witnesses are scheduled so far—William Horne Jr. of **Olin Mathieson Corp.** and Charles Orem Jr. of **Sylvania Electric Products Corp.** There should be several more, if industry hopes to build a case for including fast tax write-offs in the reform bill.

There seems to be no escaping the fact . . . that the Soviet bullseye on the moon has failed to register any effect on the U.S. space program. There will be no step-up: that's the word from NASA Chief T. Keith Glennan. And it comes as no surprise, for the Administration has been noticeably lacking in enthusiasm for overtaking Russia in the space race.

Many people in industry apparently are reconciled to the fact that no changes will be forthcoming for some time and are keeping space proposals in their pockets. A top official of one of the nation's leading missile/space companies summed it up rather bluntly to M/R the other day. Said he:

"Our company has made a policy decision to concentrate on fundamental research for the next year and half—until the administration changes."

Leak Detector is Easily Serviced

New features for reduced maintenance downtime and improved performance are incorporated in a redesigned mass spectrometer leak detector now available from **General Electric.**

Among improvements for the new model are a quick-change self-aligning filament, a new automatic balance measurement circuit, enlarged capacity vacuum pumps, new easy-to-read panel meters, and general maintenance improvements.

The M-60 mass spectrometer leak detector locates leaks as small as 1x10^{-10} cubic centimeters of air per second, so small that less than one cubic inch of air at atmosphere pressure would pass through in 5,000 years. It is used to check vacuum tubes, transistors, valves, connectors, missile devices, nuclear systems, and other products where extremely small leaks may seriously impair quality.

Leaks are located by applying helium tracer gas to one side of the enclosure while the leak detector draws a sample of air from the other. If helium is present in the gas analyzed by the detector, an alarm is given.

Among maintenance improvements in the new M-60 unit is a quick change filament procedure that is performed without shutting down the vacuum pumping system. Downtime required for replacing the filament is less than five minutes, as opposed to thirty minutes to an hour in previous models.

The M-60 also features platinum-clad ion repeller that can be flame-cleaned during the same five-minute period. According to company engineers, flame cleaning eliminates the more time-consuming abrasion and rinse method used normally in this type leak detector.

Maintenance of the electronic portions of the M-60 model has been simplified by mounting the components on individual removable panels according to their basic function. Convenient check points for the complete circuit are located on one connector strip.

An improved vacuum pumping system can exhaust the units to operating pressure in about thirty minutes from a cold start. Consisting of a 60-liter-per-second, air-cooled diffusion pump and a 1.2 cfm mechanical pump, the system is believed to have the largest capacity supplied with any mass spectrometer leak detector.

The stainless-steel vacuum system includes a new low-loss cold trap that requires less than one-half liter of nitrogen every eight hours—about half that needed by other available models. The new wide-mouth allows filling without a funnel, and permits use of dry ice-acetone as the refrigerant.

The filament is protected by an over-pressure circuit, triggered by an easy-to-clean, cold-cathode-type vacuum gauge that cuts off filament power when pressure exceeds a safe operating value.

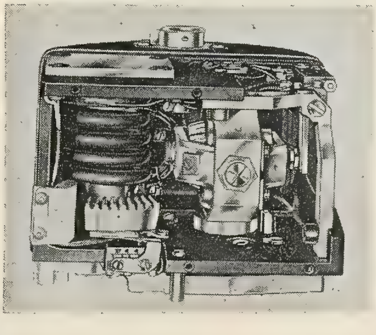
A new automatic balance circuit allows the M-60 unit to operate effectively despite the presence of helium within its sensing circuit, company engineers said. While other available mass spectrometer leak detectors often require an hour's wait to dissipate helium contamination after encountering large leaks, they reported, the M-60's automatic balance circuit eliminates this time delay because it limits detection to increases in helium concentration.

General Electric
Schenectady, 5, N. Y.

Gyro Guidance Control Unit is Economical

A two-degree-of-freedom gyro whose rotor is energized in a fraction of a second by wound helical spring has been developed and manufactured by **Waltham Precision Instrument Co.**

Providing guidance over a period of several minutes—applicable to short range missiles and target drones, Waltham's spring driven gyro is comparatively simple and consequently more rugged and reliable.



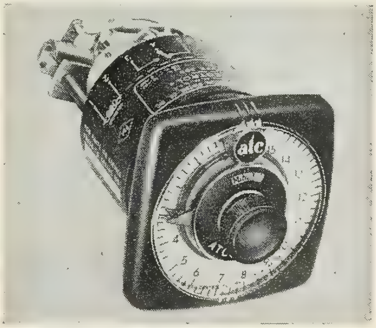
The spin axis of this new gyro is along the pitch axis of the missile; the outer gimbal is along the roll axis; and the inner gimbal is along the yaw axis. A potentiometer pick-off about the outer gimbal axis indicates the angle of roll. For short duration guidance, no erection system is necessary.

In operation, the WG-14 gyroscope is caged before take-off or launching. The starting signal releases the wound spring which energizes the rotor. When the rotor is up to speed, the gyro uncages and acts as a free gyro during flight. Effective angular momentum is maintained for a period of 3 minutes after firing and drift rate is controlled at less than 1 degree per minute.

Waltham Precision Instrument Co.,
221 Crescent St.
Waltham, 54, Mass.

DC Timer Features Automatic Reset

A direct current reset timer for automatic control of industrial and machine process functions has been made available by **Automatic Timing & Controls.**



This timer is a DC version of the Atcotrol Series 305 miniature reset timer designed for AC operation. The DC Series 305 will control DC loads within variable timed intervals or sequences with a repeat accuracy of ¼ of one percent. It will reset full scale length in less than 1/10th of a second, or stop on power failure or power interruption.

Seven basic circuit arrangements provide an infinite number of combinations for control of automatic functions, and exclusive metal to neoprene impingement clutch allows millions of operations without clutch wear or slippage. The Series 305 also features self-cleaning heavy duty silver contacts and a wiring schematic printed on the cover to eliminate errors in circuit identification.

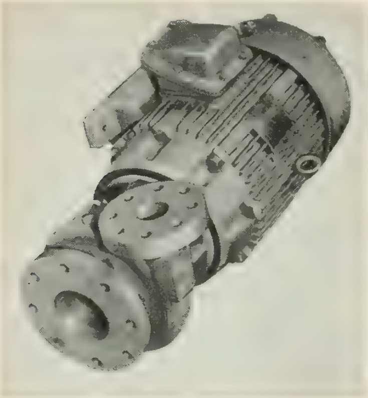
Two or more Series 305 Timers can be combined for repeat cycle operation, with each timer adjustable to be desired timing interval, either for reset or non-reset on power failure.

Automatic Timing & Controls Inc.
King of Prussia, Pa.

Transfer Pumps Have 8,000 gpm Capacity

A family of close-coupled (built on) petrochemical and cryogenic transfer pumps, for high-flow continuous or intermittent duty from 10-8,000 gpm capacity with differential pressures up to 300 psi outlet, is available from **Turbocraft, Inc.**

Known as the Series 3000, the Turbocraft units operate at low values of net positive suction head (NPSH) without adversely affecting performance. The pumps are supplied close-coupled (built-on) to an electric motor drive. A complete range of separate bearings housing allows direct coupling to other drives such as steam or gas turbines, and hydraulic motors.



Advantages of the Series 3000 are said to include minimum maintenance, horizontal or vertical mounting, and easy removal from the system without affecting suction or discharge piping. Of particular interest in cryogenic applications are the minimum "wet end" weight to reduce "cool-down" time and minimize loss of liquid; open construction between pump and drive to reduce hazardous collection of gas in the pump area; and the use of a thermal barrier between pump and motor to minimize heat transfer.

The pump can be supplied with two types of mechanical seals: conventional seal or packing for normal applications, or the Turbocraft all-metal Series AMB shaft "bellows" seal for severe environments such as cryogenics.

A wide range of materials is available for either the cryogenic or petrochemical applications to meet special requirements or weight or corrosion resistance.

Turbocraft Inc.
492 E. Union St.
Pasadena, Calif.

Recording Equipment Has Extended Low Frequencies

A new recording/reproducing system with greatly increased capabilities has been delivered to **Sandia Corp.** by the **Mincom Division of Minnesota Mining and Manufacturing Company.** The system, Mincom's model CV-107, has an extended low frequency range through the use of fm lows.

The low frequency range extension is provided by the inclusion of three fm tracks capable of accommodating frequencies from ½ cycle to 100 kilocycles. The three tracks will operate simultaneously with four analog tracks, with a frequency response of 400 cycles to one megacycle.

Sandia's application for the CV-107 is twofold: measurement of time intervals in the mc range, and recording of transient wave forms. This latter function will utilize the entire video bandwidths provided by the system.

A three-mode operational capability is afforded by CV-107, and it will accommodate the following: Seven direct-recording and playback channels with a frequency on each track ranging from 400 cycles to one megacycle; four analog tracks from 400 cycles to one megacycle, along with three fm tracks from ½ cycle to 100 kilocycles; and three channels composed of fm lows and analog highs, giving full bandwidths ranging from ½ cycle to one megacycle, plus an additional track with a frequency response ranging from 400 cycles to one megacycle.

Mincom Division
Minnesota Mining & Mfg. Co.
2049 S. Barrington Ave.
Los Angeles 25, Calif.

Sensing Device Aids Control Technology

Brush Instruments, a division of the **Clevite Corp.,** has developed a new sensing device which is said to overcome many of the obstacles that have plagued control instrumentation for many years.

The new motion sensing device—known as "Metrisite"—is essentially a type of transducer which has a unique near-perfect combination of desired performance characteristics . . . said to be several orders of magnitude greater than any other transducer or control device.

Resolution of the device is said to be such that measurements as small as one ten-millionth of an inch can be made with ease. The limit of resolution is dependent only on the mechanical system with which it is used.

An extremely light operating force will activate the Metrisite's one moving element due to minimum bearing friction and low inertia. Reactive force is so low (a fraction of a milligram in most cases) that the monitoring of the system under control cannot be detected.

True linearity is achieved from zero to full range due to the absence of hysteresis losses. Production models have a proven linearity of 1/10th%.

Electrical output is of such a magnitude that the Metrisite can provide full-scale operation of a sensitive rectified-type meter directly without an amplifier. Units have been made with outputs as high as 100 volts.

Metrisites adapt a variety of configurations from subminiature to sizes capable of measuring over four inches of linear motion. Units are in production to measure directly either angular or linear movements, and thus eliminate complex or error-producing mechanical linkages.

Brush Instruments
37th and Porkins
Cleveland, 14, O.

Resistor Sizes Cut by One-Half

A totally new method of deposited carbon resistor manufacturing by the **International Resistance Company** has resulted in reduction in size and weight of resistors by more than 50%.

The technological breakthrough which signalled this important advance was the development of a radical new deposited carbon alloy, but this in turn required a redesign of almost every element in the resistor. An insulating spiral path, which determines the resistance value, is now diamond-cut in the much harder alloy film, rather than sand-blasted as formerly. The result is a much more precise incision, with consequent improvement in stability and reliability.

The highly conductive terminating point, which bonds the end-cap connections to the film, is still another new development. Over the resistance element are two new types of moisture resistant undercoat, also especially developed for this product.

Completing the double-barrier insulation is a new-type molded, break-resistant casing, which, though heavy duty, is well within MIL size. This molded insulation results in improved load-life characteristics, better dielectric characteristics, and greater opposition to the effects of moisture. It provides all the advantages of ceramic solder sealed types, without the hazards of seal leakage, breakage and low dielectric strength.

These radically improved resistors are available in ¼ watt, ½ watt and 1 watt sizes, in resistances from 10 ohms to 25 megohms. Standard tolerance is 1%, although 0.5 and 2% types are also available.

International Resistance Company
401 N. Broad St.
Philadelphia 8, Pa.

Total Reliability Claimed for Cryogenic Value

A relief valve for cryogenic service, Model K5120T, said to be totally reliable is now available from **James, Pond and Clark, Inc.**

The new valve, with both body and spring of stainless steel, is designed for use in liquid oxygen or nitrogen systems. It is available with cracking pressures ranging from 100 psi to 2400 psi.

The in-line design of the valve provides ease of mounting, lightweight construction and exceptional flow characteristics without the complications arising from pilot operation.

The poppet ports open fully when the valve starts to crack, but the flow is throttled between the poppet shoulder and seat, providing regularly increasing flow area with increasing flow rates. When the valve is closing, a spring equalizer transmits only the axial component of spring force to the poppet, causing it to slide smoothly in the bore. This provides even "O" Ring seating against the sealing surface.

The Teflon "O" Ring is effectively removed from the flow pattern when the valve is open, and provides a dead tight seal when the valve is closed. This dead tight seal prevails at normal system pressures against the passage of liquids or gases at temperatures down to –320° F.

The K5120T is manufactured with tube connections in sizes from ¼" to 1" and is also available in pipe sizes from ⅛" to 1".

James, Pond and Clark, Inc.
2181 East Foothill Blvd.,
Pasadena, Calif.

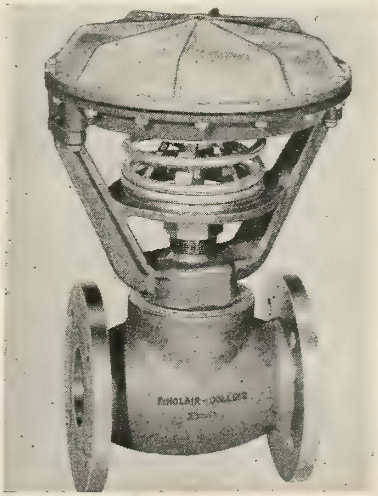
Vacuum Valve Has High Flow Rate

A line of diaphragm-operated vacuum valves, for use in vacuum processing applications where high flow rates and positive sealing are of importance has been produced by the **Sinclair-Collins Valve Co.**

Capable of sealing and holding vacuum to within .5 inches Hg absolute for an indefinite period of time, the new valves feature resilient synthetic O-ring seat seals combined with direct metal-to-metal seat stops to give a positive seal without O-ring deterioration in heavy-duty service. According to the manufacturer, side-to-side contact of the O-ring seal with the seat plus specially designed stem packers assure consistent leak-free performance and longest possible service life.

S-C vacuum valves are offered in flange or screw-mounted 2-way types, and in sizes up to 3 in. NPT. Valve bodies are of Navy M bronze, with Monel stems and stainless steel trim. Full interchangeability of parts simplifies in-service maintenance. The valves are designed for actuation by any suitable pneumatic or electro-pneumatic pilot, cycle control unit, or for remote manual operation.

Sinclair-Collins also manufactures a complete line of ½ to 3 in. NPT diaphragm-operated medium and high pressure control valves for oil, air, steam gas and hot or cold raw water service, as well as a variety of automatic valves for special applications.



Sinclair-Collins Valve Co.
454 Morgan Ave.
Akron, 11, O.

Compactness Featured In New Scanner

A compact, self stepping crossbar scanner complete with optional remote dial control is currently being marketed by **James Cunningham Son & Co., Inc.**

The unit, an adaptation of crossbar equipment in wide use throughout the electrical and electronic industries, was developed as a portable, high-capacity pilot plant or laboratory testing device.

Designated Model SC-5F, this latest scanner is a modified Cunningham Type F crossbar switch with simplified drive circuitry enabling it to connect sequentially a six-wire circuit to each of 100 sets of six-wire terminals at up to 50 sets per second. The six wires can be further divided into single-, double-, and three-wire circuits. Though the Model SC-5F takes up only 27" of standard 19" relay rack space fully assembled with power supply control chassis and switch chassis, it is designed for reliable operation without service or adjustment over millions of cycles with low crosstalk between adjacent circuits at frequencies up to 10 megacycles.

Because of its twin gold contacts with 30 gram minimum contact pressure which permits scanning of low level signals, it is readily adaptable for thermo-couple and strain gauge scanning. Other typical applications include testing and selecting automatic circuits, diode and transister testing, instrumentation computer and data processing. The unit is unique in that it can scan sequentially as well as at random. Three modes of control are available; self pulsing, external pulsing and random access by means of a telephone dial.

The Cunningham Model SC-5F scanner has a bridging capacity of 20 mmfd. to ground and between conductors. Breakdown voltage: not less than 1500 VAC between switching conductors and frame and across switching contacts. Insulation resistance: 10,000 megohms and higher. Conductor resistance through longest path: 0.3 ohms. Current carrying capacity: 100 milliamps non-inductive at 50 VDC for 20,000,000 operations. Contact bounce less than 200 microseconds on make; none on break.

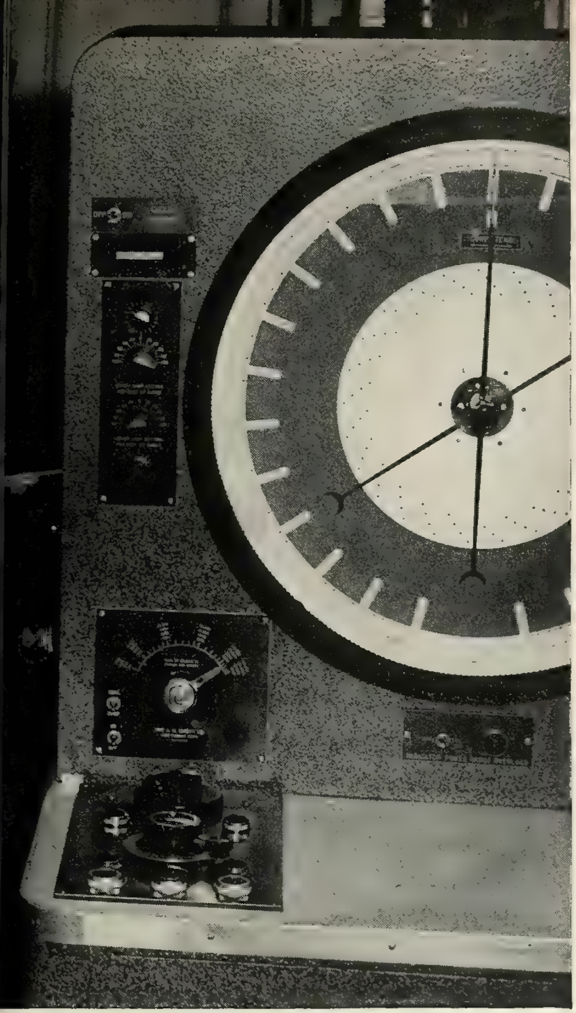
James Cunningham Son & Co.
101 Litchfield St.
Rochester 8, N.Y.

WHO READS MISSILES AND ROCKETS?

Well, for example . . . TOP ENGINEERS AT MARTIN

Martin Company engineers have successfully fabricated stress-resistant sheets which have been used to build the *world's first beryllium structure* in accordance with primary structural standards. Until now, however, the extreme brittleness of beryllium has been the stumbling block to fabricating sheets that will meet the structural requirements of space flight.

Beryllium has exciting possibilities as a major structural material for missiles, rockets and space vehicles. It is very strong and light. Only 70% as heavy as aluminum, it has the strength of the best aluminum alloy and a stiffness 1 and 1/2 times that of steel. It is an excellent absorber of heat, having a specific heat more than twice that of other structural materials and a melting point more than twice that of aluminum.

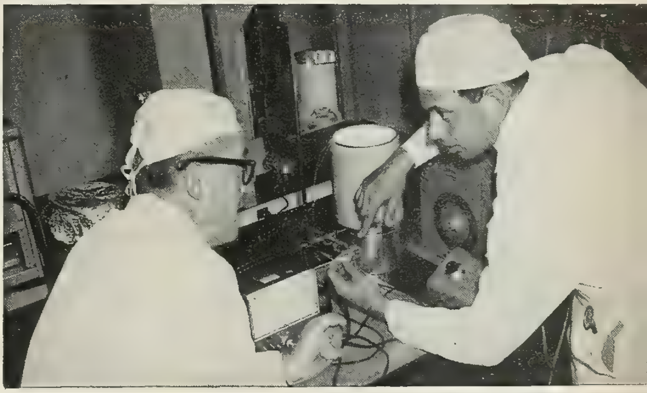


BERYLLIUM BREAKTHROUGH Charles J. Giemza, (left), Supervisor of Metals Research at The Martin Company, discusses the testing of structural beryllium with William Howard of the editorial staff of Missiles and Rockets magazine. Mr. Giemza recently received the Achievement of the Year Award from the American Rocket Society for his part in the development of structural beryllium. The use of beryllium as developed by The Martin Company will make it possible to solve many of the aerodynamic and structural heating problems associated with space flights and re-entry into the earth's atmosphere at speeds up to 18,000 miles per hour.

"Today's missile and astronautics engineer must know the products and capabilities of the *other* companies throughout the industry. Here's where Missiles and Rockets magazine fills the bill." — Richard Allen, (right), Scientist, Cryogenics, Research and Development.

"Why do we like Missiles and Rockets magazine? The answer is simple. Missiles and Rockets deals exclusively with *astronautics.* Missilery and outer space exploration today is an industry by itself, long divorced from aviation." — Robert R. Drummond, (left), Chief, Structures Research, Martin — Baltimore. Eric L. Strauss, (right), Supervisor of Non-Metals Research, shows extreme high temperature test examples of ceramics and plastics being developed for re-entry vehicles.

"News to the missile engineer *must be news* and must be technical . . . on a frequent basis — not a month old. From concept to proven flight — it takes thousands of parts from hundreds of companies to put a bird in the air." — Jack Lennard, Scientist, Research and Development.



WHY YOU SHOULD ADVERTISE IN MISSILES AND ROCKETS . . . Missiles and Rockets has *no waste* circulation—just those who manufacture missiles, space vehicles and allied equipment—and active Government and military personnel. *Over 29,000 missile technicians pay for their subscriptions to Missiles and Rockets*—the *best* circulation story among magazines covering the missile market. Missiles and Rockets reaches the thousands of companies, NASA and the Department of Defense who are purchasers in this multi-billion dollar market.

TELL YOUR PRODUCT OR CAPABILITY STORY THROUGH THE PAGES OF MISSILES AND ROCKETS—THE TECHNICAL/NEWS WEEKLY OF THE MISSILE/SPACE MARKET.

missiles and rockets

AN AMERICAN AVIATION PUBLICATION

1001 VERMONT AVENUE, N. W., WASHINGTON 5, D. C.

people

HOLMES

Jay Holmes and **John F. Judge** have been appointed associate editors of chemistry and propulsion for MISSILES AND ROCKETS magazine. The appointment of these two men follows the magazine's policy of increased technical news coverage of the missile/space market. It has opened a more specialized department to give exclusive coverage to the physics and chemistry of prime interest to engineers and military.

Holmes, a graduate of Queen's College in New York, has been awarded a certificate from the advanced science writing program of the Graduate School of Journalism, Columbia University, where he specialized in technical writing geared to the Missile/Space Age. Holmes served as New York correspondent for M/R and also spent a number of years with the AP in the same area. He recently authored a book, "The Nature of The Atom" for the Doubleday Science Club. During and after World War II he served with the Army counterintelligence corps as a special agent.

JUDGE

Judge came to M/R from the Patent Department of the Union Carbide Corp. He received his B.S. in chemistry from LeMoyne College in Syracuse, N.Y., and was formerly a research chemist for the Harris Research Laboratories in Washington. He is a member of the American Chemical Society.

Gordon N. Smith has been named chief engineer of the recently formed Monitor and Control Division of Fenwal Inc. Smith was previously associated with Paige Industrial Corp. and prior to that Electronics Corp. of America.

Several engineering staff changes have been announced by Daystrom Transicoil, division of Daystrom, Inc., as part of an overall "growth and expansion plan:" **William Hargeaves,** vice president, engineering, becomes engineering assistant to the general manager; **Dwight Bloser** vice president, engineering, takes charge of special projects; **Panos Yeannakis** is made chief engineer and **Carmine D'Amico** becomes assistant chief engineer.

Dr. Everett T. Welmers, director of plans and programs for Bell Aircraft Corp., has been selected to work with the Department of Defense's Advanced Research Projects Agency on special space projects.

Dr. Welmers, who has been with Bell Aircraft since 1944, has been granted a one-year leave of absence and will join ARPA on September 14.

REILY

Atlantic Research Corp. has announced that **Philip K. Reily, Jr.,** assistant to the president, has assumed responsibility for the firm's Development Department. Reily replaces **DeWitt O. Myatt,** who has resigned to start his own research and consulting firm in science communications and is now a consultant on development to Atlantic Research.

Prior to joining ARC in 1956, Reily was director of the Solid Propellant Information Agency of Johns Hopkins University Applied Physics Laboratory. He has published articles on solid propellants and has patents pending on the stabilization of aralkyl halides.

Other new members of the Development Department are: **William S. Jones, David B. Roberts, B. Brooke Bright, Floyd Swanson, John W. Selph** and **John Sodolski.**

Jones, previously in Government service, is in charge of research project development activities.

Bright, formerly on the staff of the National Science Foundation, has joined the technical personnel recruitment staff.

Roberts and Selph, chemical engineers, are conducting project development and liaison work for the company's rocket activities. Roberts was formerly with the nuclear engineering operations of Westinghouse Electric Corp. and Selph worked with Eastern Gas and Fuel Association as a senior research engineer.

Swanson, formerly of Giannini Controls Corp., is assigned to the development of new projects in electronics, acoustics, instrumentation and physics for the company's electromechanical division.

Sodolski will be engaged in development, administration and management services.

SPONSLER

Dr. George C. Sponsler III has been appointed a senior scientist at Hoffman Electronics Corp.'s Science Center, to head a newly-formed system study group. He will direct a scientific team charged with developing studies in satellite communications and anti-submarine warfare. He has authored journal articles and technical reports and was formerly with the Office of Naval Research where he was in charge of the Naval Analysis Earth-Satellite Study.

John Robert Clark, Jr. has joined the Washington office of Thiokol Chemical Corp. Clark will work on matters dealing with technical and contractural liaison with various agencies of the Dept. of Defense and with prime contractors having major rocket systems from the government.

Space Electronics Corp. has appointed **Irving Stokes** to the newly established position of chief engineer. Stokes was previously with RCA as manager, Advanced Projects and Planning in the Missile and Surface Radar Dept. Prior to joining RCA in 1955, he was deputy director of the Radar Division of Engineering Laboratories and holds four patents in radar and IFF techniques.

WHITMORE

Lockheed Missiles and Space Division has announced the appointment of **Dr. William F. Whitmore,** nationally-known expert in military operations research and weapons system evaluation, as a consultant scientist on the chief scientist's staff. He will concentrate on problems associated with Navy weapons systems and will conduct various operational research studies and system evaluations.

Prior to joining Lockheed, Dr. Whitmore was chief scientist to the Director of the Special Projects Office, U.S. Navy Bureau of Ordnance.

RATYNSKI

Milton V. Ratynski has accepted a position as Director of Engineering with Craig Systems, Inc. He will supervise research design and development activities and coordinate the work of the electronics, mechanical and research departments. Ratynski previously served as chief of the General Engineering Laboratory with the Air Force Rome Air Development Center. His prior associations were with the Signal Corps Engineering Laboratories, National Broadcasting Co., Hercules Powder Co. and Ryerson Steel Co.

Richard W. Black has been named government project engineer at Vitro Engineering Co. division of Vitro Corporation of America. Black was formerly manager of the Baltimore division of Burns and Roe, Inc., consulting engineers, and prior to that project engineer for Conlan Electric Corp.

propulsion engineering...

By M/R STAFF

Callery Chemical's parent company . . .

Mine Safety Appliances, stays in the space business despite cancellation of boron fuel production contracts—thanks to MSA's long familiarity with gas absorbing chemicals, gas properties and analysis. NASA has awarded MSA Research Corp. a $70,000 contract to study two super oxides as possible oxygen suppliers to manned space flights. They are potassium super oxide (KO_2) and sodium super oxide (NaO_2).

Next step is propellant oxidizers . . .

at least that's the conclusion observers draw from MSA's enthusiasm for a contract so small in dollar value. This will be afield from MSA's work in mine gas analysis techniques and devices, but so was the **Callery** boron venture. The super oxides themselves probably will not become propellant oxidizers, but merely provide the hook on which the company hangs its "legitimate interest" in oxidizers. Work with the super oxides can lead to the build-up in facilities, manpower, and knowledge that might make MSA want to jump into the missile propellant field with both feet—*and salvage Callery's work on boron.*

Callery is out of business otherwise . . .

so Dr. W. H. Schechter, Callery vice pres., told the House Committee on Science and Astronautics. Now that the limited amounts of boron fuels are no longer needed for evaluation in manned aircraft, he says, they can be used in research leading to boron missile fuels. Since some studies already have ruled out this possibility, observers believe MSA will try to save Callery via the other route—oxidizers.

Most significant remarks on Russian rockets . . .

made during the House Committee attempt to determine whether the USSR really did launch a rocket in the direction of the moon last January, came from Col. Linscott Hall, Air Force Intelligence. He testified that our information indicates the Russians "are quite good in their guidance systems, in their propulsion systems." He added the customary qualifier that the Russians had a head start on the U.S., but then went a step further—a significant step, the Committee felt—in saying that we still have a way to go to "catch up with the Soviet in terms of guidance and propulsion."

Exactly how we are behind . . .

in propulsion has never been made clear in any of the voluminous testimony indicating we definitely trail Russia in propulsion. Is our failure one of chemistry or one of engineering—do we lack the propellants or do we lack the plumbing?

It's the plumbing . . .

said top missile people who were queried by M/R. The consensus reads about like this: "We have the propellants, are probably neck and neck with the Reds in the propellant battle; we even have equally good propulsion systems, but they simply make their plumbing larger—blast off with brute force." These missilemen, in and out of government, say we could do the same but all it would prove is that "A bigger pile of dynamite makes a bigger explosion."

Free radicals remain a top item . . .

for scientific research, but not as possible propellants. This is the conclusion of the National Bureau of Standards' Fourth International Symposium on Free Radical Stabilization. It agrees with a report Air Force scientists are now drafting to the effect that free radical study will continue as a means of learning more about chemical reactions, but not with an eye on free radical propulsion. The National Bureau of Standards three-year crash program on free radical research is coming to an end, but the Bureau will continue basic studies on a smaller scale.

Expanding the Frontiers of Space Technology in

MANUFACTURING ENGINEERING

■ Lockheed Missiles and Space Division maintains complete manufacturing laboratories for research in chemistry, metallurgy, plastics, and electronics. Engineering, design, fabrication, and installation services are performed in such areas as magnetics, hydraulics, optics, electronics, pneumatics, and mechanics.

Manufacturing production techniques, such as ultrasonic drilling of microscopic holes in extremely hard and dense materials, are developed by the laboratories. Electronics and solid state research makes possible smaller, lighter, and increasingly reliable components and systems for accurate guidance, sensing and communication at extremes of temperature, vibration and acceleration.

ENGINEERS AND SCIENTISTS

The advanced nature of Lockheed Missiles and Space Division's programs provides an unusual opportunity for qualified professional men. If you are experienced in work related to the above areas, you are invited to share in the future of a company that has a history of continual progress. Write: Research and Development Staff, Dept. I-4-29, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM; DISCOVERER, SENTRY and MIDAS; Army KINGFISHER; Air Force Q-5 and X-7

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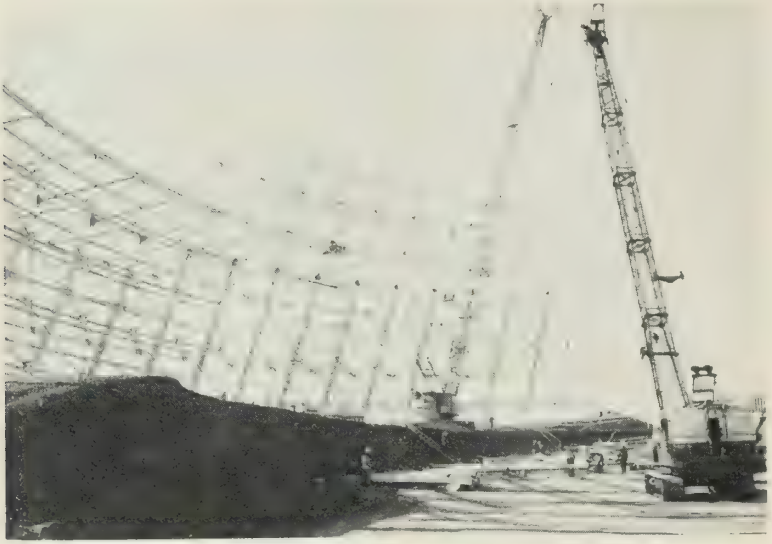
BMEWS Rises in the Arctic



THE FIRST STATION of the huge Ballistic Missile Early Warning System is being built at Thule, Greenland. Another far less along is being built at Clear, Alaska. Another may be built in Scotland. The giant radars designed to detect oncoming ICBMs 3000 miles away are supported by huge stays capable of supporting them in a 185-mile-an-hour wind. The multimillion-dollar system is being constructed for the Air Force by the Army Corps of Engineers. The Defense Department in releasing these pictures identified the location only as "the wind-whipped Arctic Circle."

Naval Research Laboratory Abandons Project ORCON

WASHINGTON—It looks like the guidance manufacturers can breathe easily again—the Navy has abandoned its "pigeon-guidance" program.

Wrapped in security for six years, Project ORCON (organic control) was a study conducted by the U.S. Naval Research Laboratory to determine whether it was practical to use specially trained pigeons as the sensing and guidance elements for homing missiles onto seagoing targets.

The use of animals as a sensing-and-control device was suggested as an answer to the effective countermeasures already developed to harass the more usual electronic and electromechanical controls.

Pigeons were selected not because of their inherent homing instincts but because they were readily obtainable, small in size and weight, and trainable.

Initial tests proved that the pigeons could be trained to peck at a distinguishable spot on a contrasting background. Grains of corn were the reward for each successful peck operation.

These first tests were halted at the end of World War II, but the project was revived again in 1948.

A simulator was devised comparable to the concept of a workable weapon system application. It was determined that a lens could be installed in the nose of a missile. The target image would be projected through the lens onto a current carrying screen. A pigeon, trained and fitted with an electrical probe, would be located behind the screen.

The pigeon, trained to peck at the most distant object on the screen, would indicate target position by the varying voltages transmitted with each peck. Pickoff of the intelligence would be directed to servo controls for suitable course correction.

- **Varying reliability**—Under test conditions, it was found that the pigeon peck frequency was sufficient to guide a 300-ft./sec. missile. Also, it was found that tracking reliability varied from 30-80%, under favorable conditions.

Biggest problem was that tracking capability was limited by visual range—that is, targets had to be easily recognizable in daylight.

The fact that none of the guidance pigeon trainees ever achieved missile flight status might lead one to believe that there was some lack of faith on the part of the Navy. One might also speculate on the flight course resulting from a weekend of shore leave, acute indigestion, or a birdlike scope image during the mating season.

—contracts

MISCELLANEOUS

$30,000,000—**Bodenseewerk Perkin-Elmer & Co. of Germany**, subsidiary of **Perkin-Elmer Corp.**, Norwalk, Conn., for producing *Sidewinder* infra-red-guided air-to-air missiles.

$157,520—**Ford Instrument Co.**, Long Island, N.Y., for design and development of inertial devices.

$50,000—**Columbia University**, N.Y., for analysis of radar noise in the *Nike*.

$49,990—**General Electric Co.**, Syracuse, N.Y., for research study entitled A Study of Thermoelectric Generator Materials.

NASA

$2,244,695—**Humphreys and Harding, Inc.**, N.Y., for construction of flight control and range operations functions of the Goddard Center.

$31,685—**Baldwin-Lima-Hamilton Corp.**, Waltham, Mass., for fatigue testing machine.

NAVY

$1,600,000—**Servonics, Inc.**, Alexandria, Va., for radar simulators.

$853,112—**Farmers Tool and Supply Co.**, Denver, for rolleron type wing assemblies for *Sidewinder* motor.

$450,000—**Allen B. DuMont Laboratories, Inc.**, for study and evaluation of test requirements for future air-to-surface and air-to-air missiles and target drones.

$35,299—**Robert & Co. Associates**, Atlanta, for the preparation of preliminary report for a *Polaris* submarine overhaul facility, Charleston, S.C.

AIR FORCE

$2,166,420—**General Electric Co., Ordnance Dept.**, Pittsfield, Mass., for long range search radar antennas.

$605,150—**The M & T Co.**, Philadelphia, for technical, non-personal operation and maintenance services for SAGE utilities systems.

$500,000—**Aeronca Manufacturing Corp.**, Longren, Calif., for chassis assemblies for the *Bomarc* IM99A missile. (Subcontract from **Boeing Aircraft Co. Aerospace Div.**)

$457,305—**American Hydrotherm Corp.**, Long Island, N.Y., for maintenance and operation services.

$439,314—**International Telephone & Telegraph Co.**, N.Y., for services for Spain-Morocco tropospheric scatter communications system.

$80,850—**Radio Corp. of America**, Harrison, N.J., for electron tubes.

$67,200—**General Electric Co.**, Owensboro, Ky., for electron tubes.

$59,570—**Bendix Aviation Corp.**, Eatontown, N.J., for electron tubes.

$26,625—**Albert Einstein Medical Center**, Philadelphia, for research and reports on the Mechanism of Action of the Thiouronium Class of Radiation Protective Agents.

$26,167—**Boston University**, for research directed toward the study of the crystal structure of appropriately selected materials of use in solar energy conversion.

ARMY

$10,995,680—**Western Electric Co.**, for continued work on *Nike-Hercules* anti-aircraft missiles.

$2,600,000—**Minneapolis-Honeywell**, for miniaturized inertial guidance systems for surveillance drones.

$772,155—**Douglas Aircraft Co.**, Santa Monica, Calif., for launching area items. (Four contracts.)

$496,703—**Brown Engineering Co. Inc.**, Huntsville, Ala., for engineering and machine shop services.

$365,745—**The Martin Co.**, Orlando, Fla., for concurrent repair parts for *Lacrosse* system.

$266,706—**Allen B. DuMont Laboratories, Inc.**, Clifton, N.J., for development and fabrication of an engineering test model electronic countermeasures set, together with instruction books, manufacturer's drawings, spare parts list and technical reports.

$240,000—**Hayes Aircraft Corp.**, Birmingham, Ala., for engineering and design services, support equipment for *Saturn* missile.

$179,900—**Samuel N. Zarpas, Inc.**, Pittsburgh, Pa., for construction of ground/air transmitter-receiver.

$179,454—**Duval Engineering & Contracting Co.**, Jacksonville, Fla., for construction of *Saturn*, complex 34, bypass road.

$149,378—**Aeronutronics Div.** of **Ford Motor Co.**, Newport Beach, Calif., for study of an infrared decoy system.

$147,622—**Hughes Aircraft Co.**, Culver City, Calif., for study and design on infrared decoy system.

$109,471—**Western Electric Co., Inc.**, N.Y., for *Nike* spare parts, components and repair parts. (Three contracts.)

$49,754—**Raymond Engineering Laboratory, Inc.**, Middletown, Conn., for research and development.

$26,711—**A. B. Cullen & Son**, Oxford, Miss., for construction of concrete launching ramps and appurtenances.

$26,253—**Duke University**, Durham, N.C., for research study in the field of microwave and radiofrequency spectroscopy.

BIDS

Dayton Air Force Depot, Gentile Air Force Station, Dayton, Ohio, Att: Directorate of Procurement and Production—Tube electron type 6W4GT S/N 5960-239-1993, 10300 ea. Tube electron type 6AW8A S/N 5960-663-7966, 7300 ea. Tube electron type 6173 S/N to be assigned, 5000 ea.—IFB 33-604-60-24B—Bid opening 2 Oct. '59.

Procurement Office, MTK, Patrick Air Force Base, Fla.—Rocket engine fuel, (UMDH) MIL-F-25604B, in non-returnable 55 gal. mild steel drums—6030 lbs.—IFB 08-606-60-46—Bid opening 29 Sept. '59.

Directorate of Procurement and Production, Kelly Air Force Base, Texas. 6635-NL11145 unit X-ray fine focal multiple foci-0.4mm and 2.5mm 150KV norelco model MG 150/3 catalogue nr 11145 or equal, 1 ea.—6635-NL12105 fluoroscope electronic image intensifier 5" fluoroscopic screen ½" viewing screen metal housing. Norelco catalogue nr 12105 or equal, 1 ea.—IFB 41-608-60-72B—Bid opening 6 Oct. '59.

Procurement Officer, National Aeronautics and Space Administration, Langley Air Force Base, Va. Pickups, pressure, electrical and pressure adapters—1 lot—IFB L-659—Bid opening 5 Oct. '59. Oscilloscopes, approx. 10 inches high by 6.8 inches wide by 17 inches deep; approx. 23.5 pounds weight—1 lot—IFB 350—Bid opening 2 Oct. '59.

Supply Officer, Naval Ordnance Laboratory, White Oak, Silver Spring, Md. Following items are procured under IFB 60921-16-60B—Bid opening 14 Oct. '59. Oscilloscopes, model 545A—2 ea.—oscilloscope, all phosphor cathode ray tube, Model 535A—1 ea.—oscilloscope, Model 551, 1 ea.—preamplifiers, dual trace, type CA, 2 ea.—preamplifiers, plug in, type 53/54D, 2 ea.—scope-mobile, type 500/53A, 1 ea.—Material as manufactured by Tektronix, Inc. or equal.

Electronics Supply Office, Great Lakes, Ill. Semiconductor device, type 1N459, MIL-E-1D, QPL, FSN N5960-543-0490—1489 ea.—alternate A, 2000 ea., alternate B, 2500 ea.—IFB 126-302-60B—Bid opening 12 Oct. '59.

U.S. Army Engineer District, Mobile, P.O. Box 1169, Mobile, Ala. Construction of IM-99B support facilities at Santa Rosa Island, Eglin AFB, Fla.—Job—IFB ENG-01-076-60-11B—plans and specs available 1 Oct. '59—Bid opening 21 Oct. '59.

Base Procurement Branch, Wright Air Development Center, Wright-Patterson AFB, Ohio. Engineering services of a testing laboratory to conduct environmental and electrical testing to determine operational suitability and reliability of components comprising part of Tacan-1FF antenna multiplexing system—Job—IFB 33-616-60-16—Bid opening 14 Oct. '59.

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letters

Refractories Research

To the Editor:

In the Aug. 31 issue of MISSILES AND ROCKETS there is a story on R&D on refractory metals which makes no mention of **McDonnell Aircraft's** work in this field.

This naturally was disappointing to our project people and to us in public relations since we had sent your magazine a release relating to an Air Force contract of $980,680 we received for refractory metal studies as related to spacecraft.

Edward J. Regan
Public Relations

To the Editor:

We read with considerable interest the article entitled "Pressing R&D on Refractory Metals" in the Missile Support section of your Aug. 31 issue.

We were, however, somewhat disappointed that **Firth Sterling** was not mentioned as one of the companies that is active in the refractory materials field. At present, we are producing large, pressed and sintered, pure tungsten rings, called Entrance Caps, for prototype models of an ICBM, which is scheduled to be operational in 1961. Further evidence of our R&D in the refractory materials field is indicated by our appointment of Dr. C. H. Toensing, recently with **General Electric Company,** as manager of our powder metals research.

I appreciate how difficult it is to keep abreast of all the companies who are active in this field, and the purpose of this letter is to ask that Firth Sterling be considered as an active participant in R&D in refractory metals, as well as in high temperature metals produced by air arc, induction vacuum, vacuum arc, and Hopkins Process melting techniques.

Thomas E. Pickering, Manager
Advertising & Sales Promotion
Firth Sterling Inc.
Pittsburgh 30, Pa.

To the Editor:

I certainly enjoyed reading your fine article on refractory metals in MISSILES AND ROCKETS for Aug. 31. Your coverage of work in this interesting field was most complete and easy to grasp. I was sorry, though, to see that **General Electric** was not listed as one of the metals companies specializing in refractory metals. Actually, we are one of the foremost producers of tungsten and molybdenum metal products in this country. The original development work on "non-sag" wire for lamp filaments was performed at GE. Through the years we have expanded our engineering and manufacturing facilities to include a rather complete line of products ranging from metal powder through rod, wire, sheet, fabricated parts, and sintered billets for forging. Today, we are one of the leading suppliers of sintered tungsten and molybdenum billets used for forging missile parts and components. Also, we are a leading supplier of electrodes made from these refractory metals used in consumable electrode vacuum arc melting.

If any future articles are planned for refractory metals, we certainly hope you will include a mention of General Electric's contributions in this field.

C. W. Irish
Marketing Section
Lamp Metals and
Components Dept.
General Electric Co.
Cleveland, Ohio

We usually prepare such survey articles well in advance and probably information was not received in time for publication. Regrets!—Ed.

Thoughts on Integrity

To the Editor:

Your editorial ("Integrity Cannot Be Legislated") in the Aug. 24 issue is a jewel! It should have been on the front cover.

J. W. Sessums
Maj. Gen. (USAF-Ret.)
Grand Central Rocket Co.
Redlands, Calif.

Incomplete Listing

To the Editor:

In your Pennsylvania-New Jersey survey (Aug. 24 issue), the list of firms engaged in missile work does not include **Stavid.** I suppose it is not possible to mention all the companies due to space requirements, but for the record let me enumerate some of our projects:

1. Development ond production of the Radar Course Directing Centrals AN/BPQ-2 (command guidance for *Regulus*); 2. Instrumentation of Project *Silo* at Edwards AFB; 3. Design and construction of Central Telemetry Facility at Edwards AFB; 4. Design and production of Radar Beacons AN/APN-91 and -92 (basic design used on *X-15* rocket); 5. Beacon telemetering and missile-borne equipment for ASSA, Ft. Monmouth.

As prime contractor to all three military services, Stavid's 1958 sales were over $11 million . . .

Albert B. Poe
Public Rel. Manager
Stavid Engineering, Inc.
Plainfield, N.J.

M/R regrets the failure to list Stavid, which obviously should have been included. It was an editorial oversight, not a result of space limitations.—Ed.

EMPLOYMENT

AERODYNAMICS

The Sandia Corporation has a need for graduates in the field of aerodynamics, aero-thermo dynamics and magneto-hydro dynamics. The work embraces research and development in the fields of space and high-altitude rockets; hypersonic research; magnetic theory; supersonic parachutes; nuclear weapon aerodynamics; and high velocity research apparatus design. Applicants with B.S., M.S., or Ph.D. degrees from accredited colleges and good academic records are requested to write Personnel Department 522, Sandia Corporation, Albuquerque, N.M.

Sandia Corporation, located in Albuquerque, N.M., is engaged in research and development of nuclear weapons and other projects for the AEC. Albuquerque is a modern city of about 225,000; has an excellent climate and many cultural and recreational attractions. Winters are mild, summer nights are cool, and there's plenty of year-around sunshine. Sandia's liberal employee benefits include generous vacations, retirement and insurance plans, and a graduate education assistance program. Paid relocation allowance.

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when and where

SEPTEMBER

Mitre Corporation, Symposium on "Tracking Acquisitions and Weapon Control in Track-While-Scan Systems," (classification—SECRET) New England Mutual Hall, Boston, Sept. 29-Oct. 1.

Institute of Radio Engineers, American Institute of Electrical Engineers, Eighth Annual Industrial Electronics Symposium, Mellon Institute, Pittsburgh, Sept. 30-Oct. 1.

OCTOBER

Institute of the Aeronautical Sciences, Anglo-American Aeronautical Conference, Hotel Astor, New York, Oct. 5-7.

Society of Automotive Engineers, National Aeronautics Meeting, Aircraft Manufacturers Forum and Aircraft Engineering Display, The Ambassador Hotel, Los Angeles, Oct. 5-10.

Electronics Industries Association Conference, University of Pennsylvania, Philadelphia, Oct. 6-7.

Radio Interference Reduction and Electronic Compatibility Conference, sponsored by the U.S. Army Signal Research and Development Laboratories, Conducted by Armour Research Foundation of Illinois Institute of Technology and Institute of Radio Engineers Professional Group on Radio Frequency Interference, Museum of Science and Industry, Chicago, Oct. 6-8.

Aeronautical/Astronautical Problems of High Speed Flight Meeting, sponsored by AFOSR/Aero Sciences Directorate, ONR, OOR, NSF, and Stanford University, Stanford, Calif. Oct. 6-8.

AFOSR/Solid State Sciences Directorate, AEC, ONR, NSF, OOR, Stanford Research Institute and several industrial organizations, International Symposium on High Temperature, Asilomar, Calif., Oct. 6-9.

AFOSR/Propulsion Research Division, Aeronautical Sciences Directorate and Avco-Everett Research Laboratory, Second Symposium on Advanced Propulsion Concepts, (Classified) Boston, Oct. 7-8.

Society of Experimental Test Pilots' Symposium, Pilot's Role in Space Exploration, Beverly Hilton Hotel, Beverly Hills, Oct. 8-10.

American Institute of Electrical Engineers, Fall General Meeting, Morrison Hotel, Chicago, Oct. 11-16.

National Electronics Conference, sponsored by American Institute of Radio Engineers, Northwestern University, and University of Illinois, Hotel Sherman, Chicago, Oct. 12-14.

Institute of Aerophysics, University of Toronto, Decennial Symposium, Toronto, Canada, Oct. 14-16.

University of Denver, Conference on Hypervelocity Projection Techniques, Denver, Oct. 20-21.

American Standards Association, Tenth National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Oct. 20-22.

Society for Experimental Stress Analysis, 1959 Annual Meeting, Hotel Pick-Fort Shelby, Detroit, Oct. 21-23.

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

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Wichita, Kansas Boulder, Colorado

editorial

So We Lag in Space—Who Cares?

The visit of Premier Khrushchev has underscored sharply the inadequacy of the nation's space program. Worse, it has brought home the dangers of our present attitude toward that program.

We have grown accustomed to the present Administration's apathy over the country's space progress in the same way an injured man gets accustomed to pain. He learns to live with it.

It is inevitable that apathy at the top level communicates itself downward; fear or hesitancy carry their own contagion. A timid leader will have timid troops.

Today this Administration's apathy over our space program has seeped down through the space agencies. It has touched Congress and the national press. It is easily visible in the American public. If our leaders show no urgency—why should the man on the street?

Between the flight of *Lunik II*, the arrival of the Soviet Premier and this writing, the United States has attempted nine assorted firings in the missile/space field. Of these, four have been successful, five have been failures. At Edwards AFB the *X-15* successfully accomplished its first powered flight—months behind schedule. It will be months more before the *X-15* carries a man into actual space. Some of these nine efforts, it could be suspected, were scheduled to time with the Khrushchev visit. None remotely approached the Russian upper-stage guidance techniques which made their moon shot possible.

What is holding up our space program? Money. Purely and simply money—and this is a sad thing indeed for the richest country in the world. It is true that the Russians began their program before we did. Time is on their side. But with money you can buy time; any honest scientist in the space/missile field will affirm that to one degree or another.

With money we can buy research, we can buy test vehicles. With money we can pursue multiple avenues of approach in the fields of metals, fuels and guidance. Recently NASA's Dr. T. Keith Glennan said that we must back off and go more slowly in space exploration because our scientific knowledge is lagging behind the program. It has, in fact, lagged for several years and Mr. Khrushchev's words remind us of that fact almost daily.

In certain fields we are not—or were not—behind. In nuclear physics, for instance, the United States led the world in every phase. Now, through that same apathy and an Administration preoccupation with the fear of inflation, we are losing even that leadership. Would you like to wager who will fly the first atomic aircraft or fire the first nuclear rocket?

The great pity of this apathy is not entirely that we may be losing ground militarily, but that we stand also to lose our leadership in our own proud specialty—world commerce and trade.

One of the nation's leading commercial scientists, speaking of the value of space achievements, said recently:

"From a purely commercial point of view a communications satellite would be worth a billion dollars to this country. A weather satellite would be worth billions.

"Whether these satellites have any military value or lead to any military usage is beside the point. They are worth what they cost without military application, but if that comes as an extra dividend, so much the better.

"Judging space exploration by its immediate returns would be like judging the value of Columbus's voyage by how much gold he brought back."

What do we need in this country to arouse the government from its tired preoccupation with elections and bookkeeping? Soviet scientists achieve a signal success by firing a rocket to the moon—a feat we tried and failed to accomplish. A space spokesman damns the achievement with faint praise and remarks that hitting the moon isn't really as difficult as hitting New York from Moscow. Maybe not, but we have a feeling the Russians might be able to do that, too.

A cherub-faced old villain from the Kremlin pays us a visit to brag piously that he doesn't consider the Soviet moon shot a Russian achievement but "our achievement"—"our" meaning the world's. The pronoun in this case sounds suspiciously possessive.

What do we need to bring about an awareness that this country is in grave danger of losing its world position militarily, scientifically and commercially? Factual evidence doesn't do it. Loss of pride doesn't do it. How fateful then will be the next 450-odd days before we have a new Administration—less tired, less preoccupied, less apathetic?

CLARKE NEWLON

FIVE YEARS THAT CONVERTED SPACE INTO A NEW FRONTIER OF FREEDOM

1954 1959

IT WAS FIVE YEARS AGO this July that a handful of men gathered in a classroom of a former parochial school in Inglewood, California, to sketch upon the blackboard of history the plans which were to give rise to the greatest single peace-time military effort ever undertaken...the U.S. Air Force Ballistic Missile Program.

Today that program involves the expenditure of nearly two billion dollars a year for the research, development, testing, production, and operational deployment of the Air Force family of missiles—Atlas, Titan, Thor, and Minuteman. These are providing much of mankind's insurance against the holocaust of thermonuclear war.

The Air Force Ballistic Missile Program is now drawing upon human and material resources which represent a cross-section of all America—thousands of scientists, engineers, technicians and others, both civilian and military, along with the countless skills and facilities exemplified by the program's 30 associate contractors, its 200 major sub-contractors, its 200,000 suppliers in 22 industries across the nation.

All these disciplines and productive capacities have been pooled into a dedicated science/industry/government team which has enabled the Air Force Ballistic Missile Program to achieve in five years what even optimists thought would take up to a decade to accomplish.

Five years ago the free world had no functional ballistic missile rocket engines, no guidance systems, no nose cones, no tracking stations, no launching pads, no trained missile squadrons. Today we have moved past the threshold of bringing these toward operational reality.

In this 14th year of the Cold War and second year of the Space Age, the Air Force Ballistic Missile Program is daily becoming more crucial to the ability of free men everywhere to survive. As this program sweeps forward, it is demonstrating anew to proven friend and potential adversary that America's military power, whether on land or sea or under it, in the air or in outer space, is first and last a power for peace—the power to deter aggression by being able to visit overwhelming retaliation upon an aggressor.

IN THIS EFFORT, in which all Americans may take pride, Space Technology Laboratories is also proud of its privilege in performing the functions of systems engineering and technical direction for the Air Force Ballistic Missile Program in close and continuing cooperation with the Air Force Ballistic Missile Division, Ballistic Missiles Center, Strategic Air Command-MIKE, with National Aeronautics and Space Administration and Advance Research Projects Agency in their advanced space probes, with the leading members of the scientific and industrial communities. All have displayed the ability to work in concert and in a spirit of patriotism which traditionally has inspired free men to turn back the threats of tyranny.

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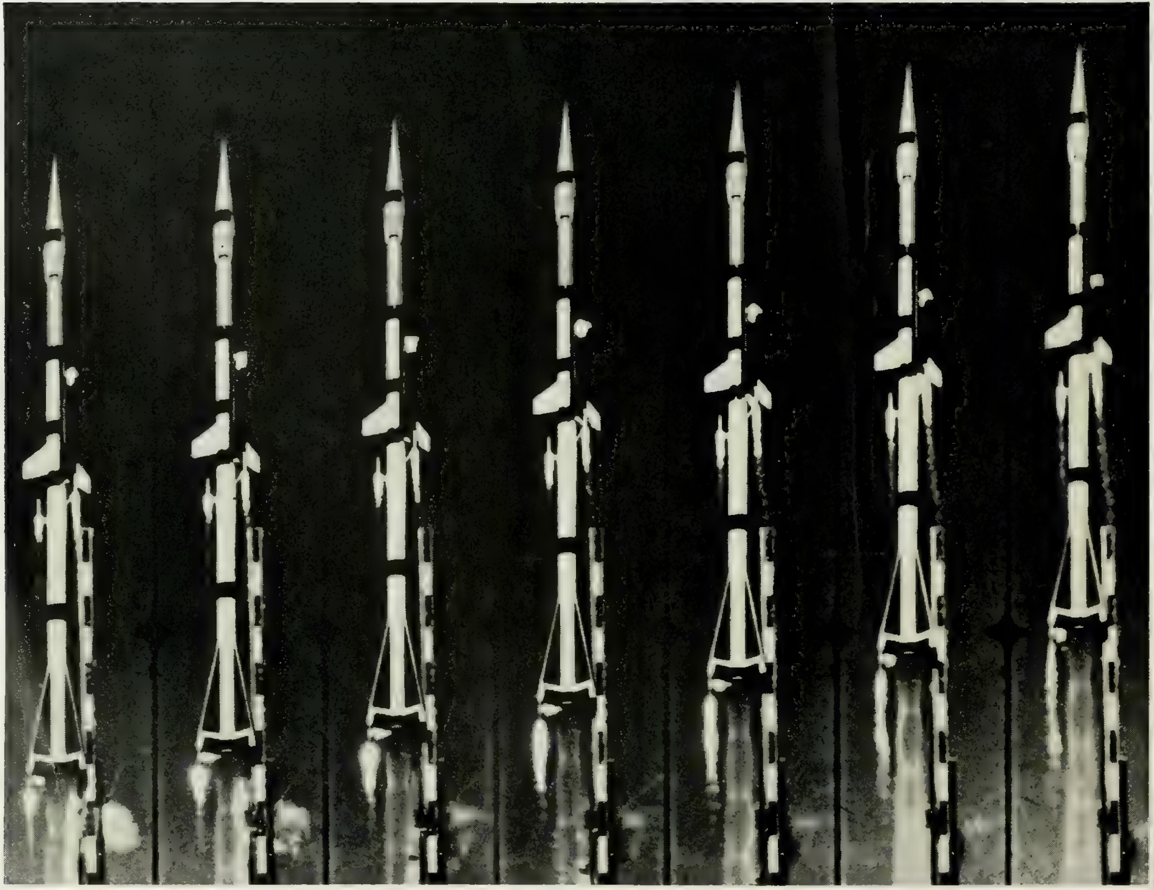
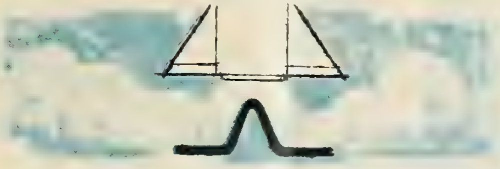


SCIENTISTS, CREATIVE ENGINEERS—INVESTIGATE THIS FIELD WITH A FUTURE. CHALLENGING WORKING ENVIRONMENT IN SOUTHERN CALIFORNIA.

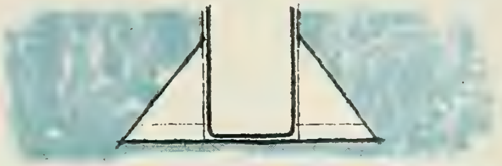
Circle No. 1 on Subscriber Service Card.

Need a NONCRITICAL *material*
to solve a CRITICAL *heat problem?*

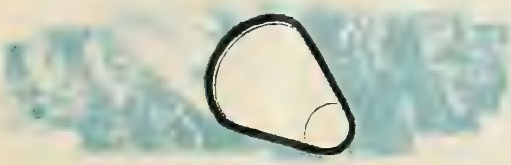
Consider these Goodyear Aircraft capabilities in the field of high-temperature laminates—



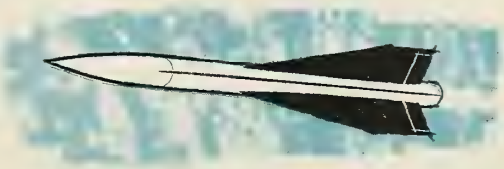
HERE'S AN INEXPENSIVE BLAST DEFLECTOR — made of reinforced plastic — which can withstand the direct blast of a rocket engine. Goodyear Aircraft stands ready to design and fabricate economical, reusable blast deflectors to your specific requirement.



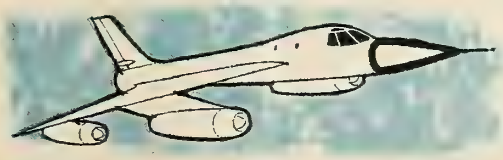
CRYOGENIC FUEL TANK INSULATION by Goodyear Aircraft is less than ¼-inch thick, yet has proved its ability to prevent "boil off" of liquid gaseous rocket fuels, such as liquid oxygen and liquid hydrogen. Use of a plastic laminate for this purpose can mean substantial weight, space and cost savings.



NOSE CONES FOR GLIDE RE-ENTRY VEHICLES can be produced at Goodyear Aircraft to a wide range of specifications. The reason: extensive experience with ablative and thermal-resistant techniques. Do you need a lightweight nose cone material that can withstand 2000° to 2500° for an hour or more? Whatever your re-entry requirement, a specially compounded high-temperature laminate may well be the answer.



LEADING EDGES OF MISSILES or aircraft can be protected against prolonged high-temperature exposure by plastic laminate coverings which conform to the metal structure. Reinforced plastic laminates by Goodyear Aircraft can also be used for jet vanes, rocket nozzles, fins and other miscellaneous missile components.



RADOMES FOR AIRCRAFT which operate at Mach III and above have been produced at Goodyear Aircraft. Goodyear Aircraft has a vast background in radome engineering and manufacturing for both the solid and honeycombed layered constructions.

"PLASTIC" MISSILES — built by Goodyear Aircraft — could utilize a variety of plastic laminates and fabrication techniques. Advantages of such all-plastic components: no use of critical material, high strength-to-weight ratio, low cost in mass production, rust- and corrosion-resistant.

Your inquiry is invited *regarding these specific capabilities—or any requirement calling for a noncritical, high-strength material which must retain its properties under the most demanding heat and stress conditions. WRITE: Goodyear Aircraft Corporation, Dept.* 916 PS *Akron 15, Ohio.*

ENGINEERED PLASTICS—*ONE OF THE PRIME CAPABILITIES OF*

GOODYEAR AIRCRAFT

PLANTS IN AKRON, OHIO, AND LITCHFIELD PARK, ARIZONA

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Cuts as fine as .008" or large frosted areas are equally easy to make with this amazing industrial tool. A gas-propelled stream of abrasive particles quickly slices or abrades, as needed, almost any hard, brittle material, such as fragile crystals, glass, oxides, metal, minerals, ceramics.

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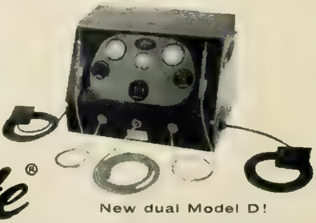

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Missiles and Rockets Volume 5 Number 41

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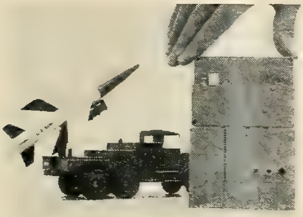
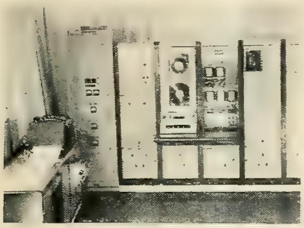
AUDITED PAID CIRCULATION ABC · NBP · READERSHIP Eastman RESEARCH · BUSINESS PAPER LEADERSHIP ABP

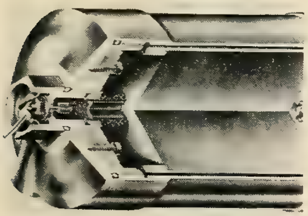
COVER: Nord Aviation *SS-10's* mounted on Bell H-13 helicopter at Ft. Rucker, Ala., where Army pilots are being trained to use the French missiles in close support of ground troops.



MARTIN's subminiaturized FM/FM telemeter for *Lacrosse* transmits 10 channels of go/no-go data. Progress in telemetry has been impeded by lack of coordination. Survey starts on p. 15.



CEC's computer input facility has editing equipment and IBM 727 tape transport (at right) for providing tape compatible with IBM 704 computer. For a report on the system, see p. 23.



AEROJET produced this pyrotechnic igniter installed in a gas generator. Pyrotechnics are probably the most-used ignition system today. A survey of the field begins on p. 30.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

31,700 copies of this issue printed

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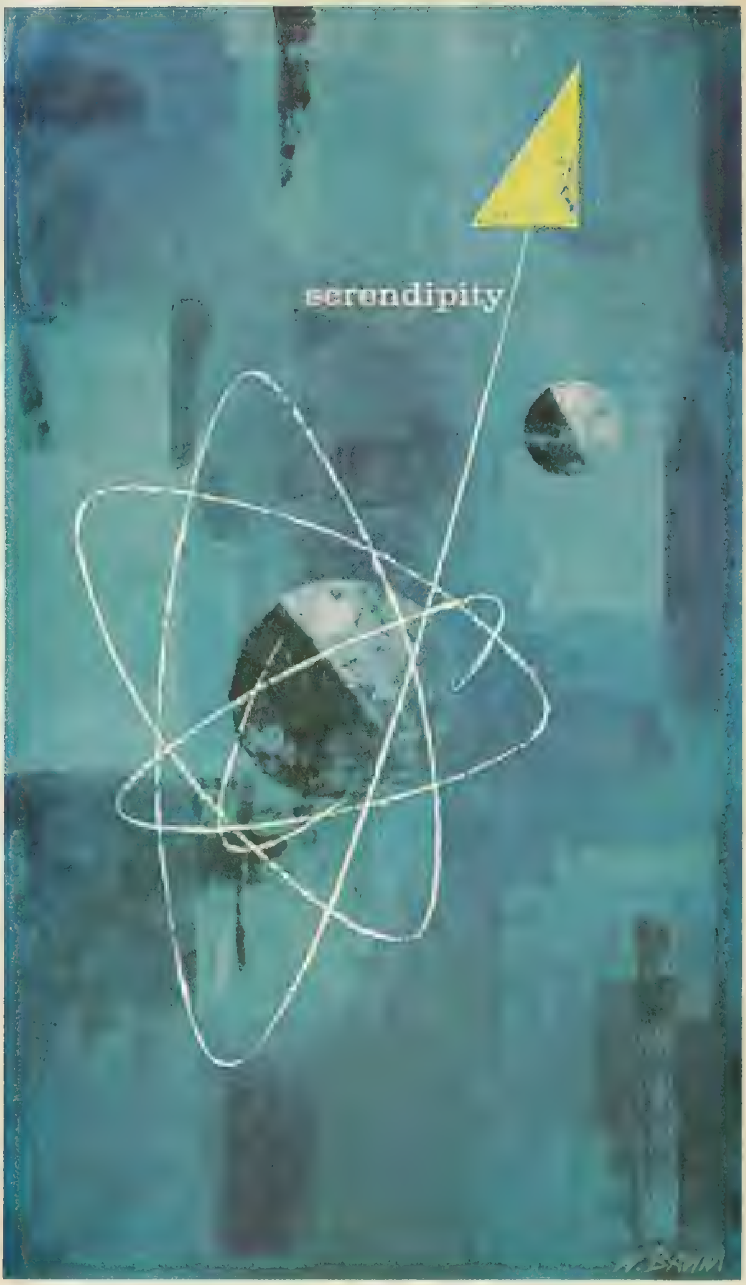

exploring the fascinations of space *and applying the knowledge gained therefrom is one aspect of serendipital intellectuality which the truly creative talent finds at Martin-Denver. If you are seeking such an experience, and desire to participate in the most advanced thinking in space science, communicate immediately with N. M. Pagan, Dept. FF-5, The Martin Company, P.O. Box 179, Denver, Colorado.*

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—when and where—

OCTOBER

Institute of the Aeronautical Sciences, Anglo-American Aeronautical Conference, Hotel Astor, New York, Oct. 5-7.

Society of Automotive Engineers, National Aeronautics Meeting, Aircraft Manufacturers Forum and Aircraft Engineering Display, The Ambassador Hotel, Los Angeles, Oct. 5-10.

Electronics Industries Association Conference, University of Pennsylvania, Philadelphia, Oct. 6-7.

Radio Interference Reduction and Electronic Compatibility Conference, sponsored by the **U.S. Army Signal Research and Development Laboratories,** conducted by Armour Research Foundation of Illinois Institute of Technology and Institute of Radio Engineers Professional Group on Radio Frequency Interference, Museum of Science and Industry, Chicago, Oct. 6-8.

Aeronautical/Astronautical Problems of High Speed Flight Meeting, Sponsors; **AFOSR/Aero Sciences Directorate, ONR, OOR, NSF,** and **Stanford University,** Stanford, Calif., Oct. 6-8.

AFOSR/Solid State Sciences Directorate, AEC, ONR, NSF, OOR, Stanford Research Institute and several industrial organizations, International Symposium on High Temperature, Asilomar, Calif., Oct. 6-9.

AFOSR/Propulsion Research Division, Aeronautical Sciences Directorate and **AVCO-Everett Research Laboratory,** Second Symposium on Advanced Propulsion Concepts, (Classified) Boston, Oct. 7-8.

Society of Experimental Test Pilots' Symposium, Pilots Role in Space Exploration, Beverly Hilton Hotel, Beverly Hills, Oct. 8-10.

American Institute of Electrical Engineers, Fall General Meeting, Morrison Hotel, Chicago, Oct. 11-16.

National Electronics Conference, sponsored by **American Institute of Radio Engineers, Northwestern University,** and **University of Illinois,** Hotel Sherman, Chicago, Oct. 12-14.

Institute of Aerophysics, University of Toronto, Decennial Symposium, Toronto, Canada, Oct. 14-16.

University of Denver, Conference on Hypervelocity Projection Techniques, Denver, Oct. 20-21.

American Standards Association, Tenth National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Oct. 20-22.

Society for Experimental Stress Analysis, 1959 Annual Meeting, Hotel Pick-Fort Shelby, Detroit, Oct. 21-23.

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

AFOSR/Mechanics Division, Aeronautical Sciences Directorate, WADC, ONR, (host) **AEC, ERDL, BUORD, BUSHIPS, BUAER, NASA, Maritime Adm.,** First International Symposium on Gas Lubricated Bearings, Washington, D.C., Oct. 26-28.

B.F.Goodrich

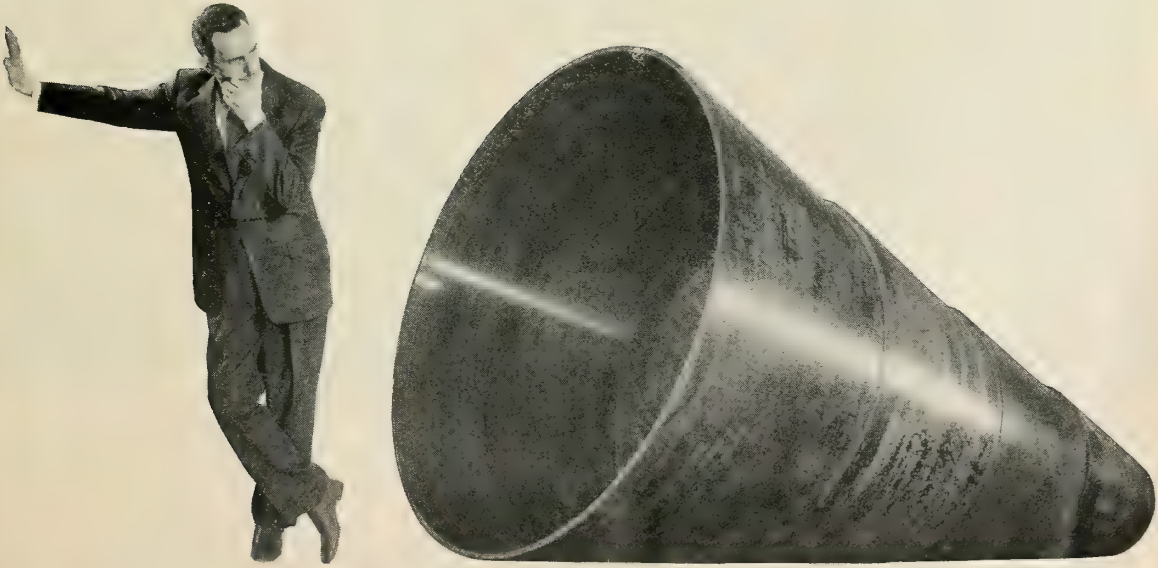
WHAT IS IT? Probably the biggest homogeneous void-free laminate ever built . . . a B. F. Goodrich ablation shield for an experimental re-entry vehicle designed and built by General Electric to be test flown on an Air Force Atlas ICBM.

Fabricated by a special B. F. Goodrich winding technique, the shield contains about five miles of high-temperature resin tape. This fabricating technique, which is also being used for many other specialized B. F. Goodrich products of various types and sizes, completely eliminates precision matched metal molds, cuts tooling costs by hundreds of thousands of dollars, and saves plenty of lead time. Autoclave curing replaces massive high pressure presses.

Throughout the construction of this re-entry vehicle shield, B. F. Goodrich maintains constant quality control of resin content and residual volatiles. Modern radiological facilities are used for final checking.

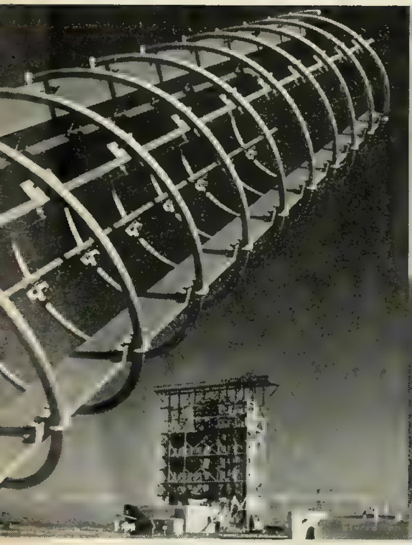
The fabrication and curing of such huge void-free parts illustrates the advances made by B. F. Goodrich in producing high-temperature, reinforced plastic products. So if you're up in the air and want down-to-earth answers on plastic laminate constructions, contact *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MR-109, Akron, Ohio.*

B.F.Goodrich *aviation products*

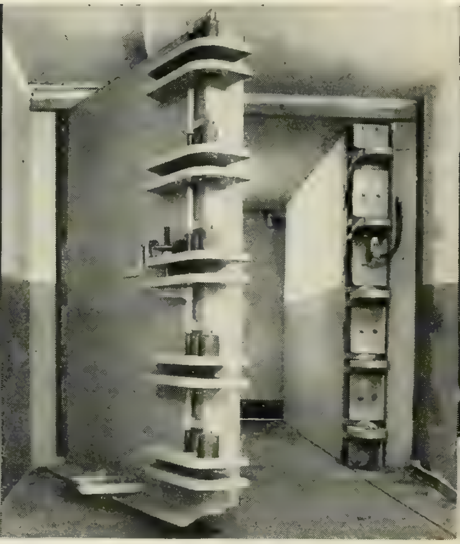


Circle No. 3 on Subscriber Service Card.

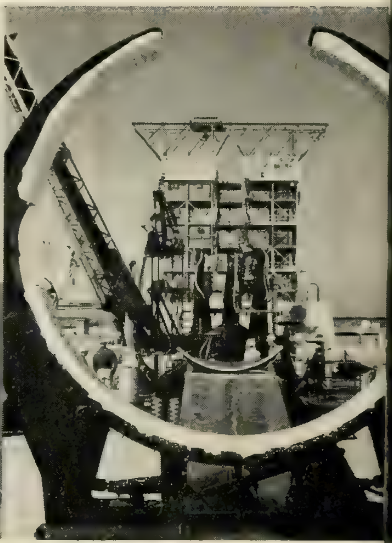
About the earthly side of Canaveral—Only recently, it spawned little more than snakes and other crawling creatures. Today, high flying birds are poised there, and because they can't jump off from sand, most of the Canaveral manpower and materials go into ground support equipment. And virtually all the steel material required can be purchased from one source—United States Steel. Whether we're talking about carbon steel, high-strength low-alloy steel, constructional alloy steel, or stainless steel, steel fence, electrical cable, wire rope or cement,



On this vertical oscillating radar tracking unit, every nut, bolt, and insulator collar is Stainless Steel. To the right, is a Stainless Steel fuel tank, and beyond that rises the U. S. Air Force Thor gantry tower, with a structural steel frame similar to a nine-story building.



The door to the U. S. Air Force Atlas blockhouse weighs 24 tons. It is solid manganese steel about eight inches thick. At X minus 15, the door automatically locks and it is blast-proof and vapor-proof.

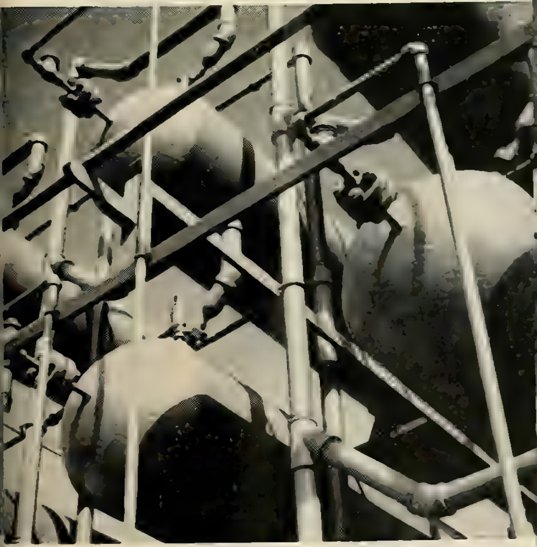


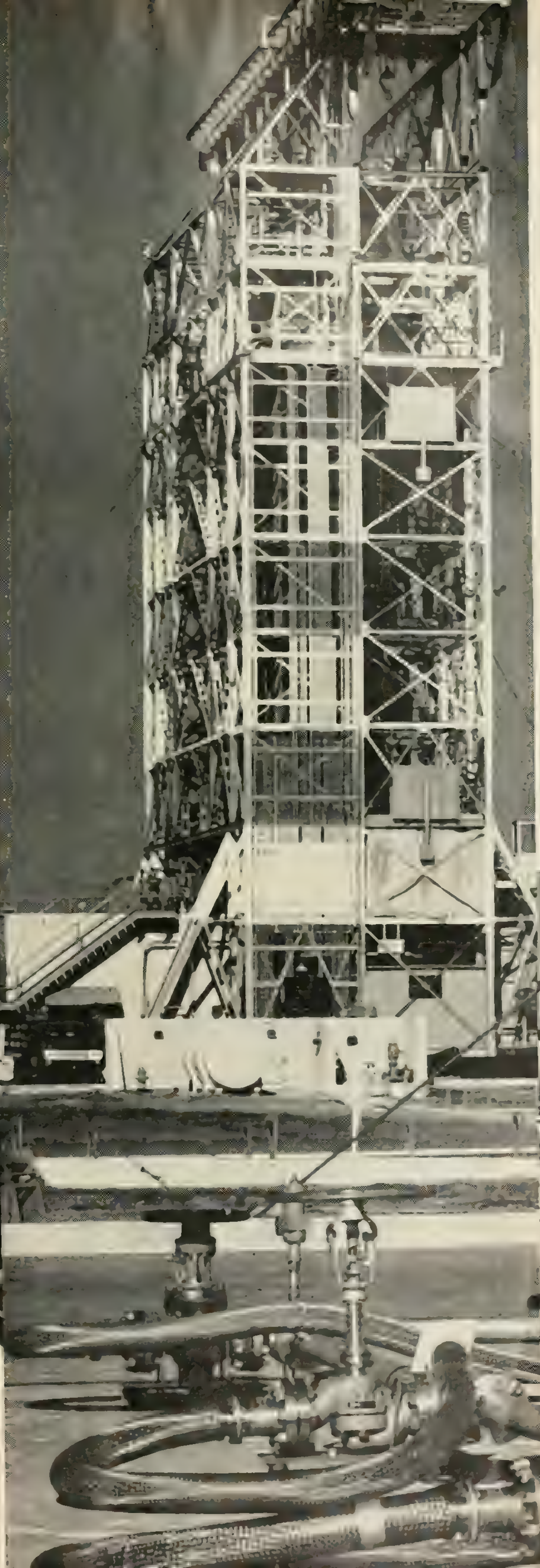
The mobile transporter for the Thor is strong but light on its wheels because it was designed with weight-saving high-strength steels. Slanting to the left is the steel umbilical tower which carries Stainless Steel fuel lines and control lines.

United States Steel maintains the technical services to provide the proper assistance to cope with any problem on these materials for ground support. When a ground support program is still on the drawing board, consult

United States Steel

USS is a registered trademark





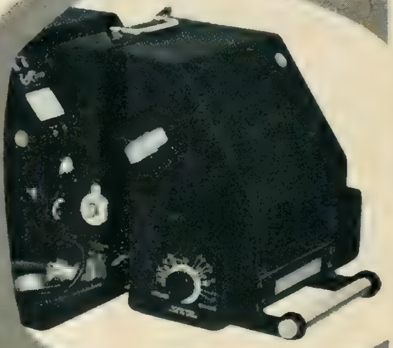
These pressure vessels for the U. S. Air Force Bomarc A system are seamless steel cylinders about 20 inches in diameter and 26½ feet long. The cylinder walls are slightly more than an inch-and-a-half thick and will contain gas at pressure up to 4500 psi.

Stainless Steel pipes and Stainless Steel flexible tubing carry the fuel for the Thor complex. Fuel lines must be almost surgically clean to prevent explosions and assure proper flow. Inspectors check the lines with everything from microscopes to ultraviolet lamps. ▶

Important news for owners of CEC's 5-114 recording oscillograph

NEW RAPID-ACCESS DATARITE MAGAZINE

provides developed, dried, fully visible records almost instantly

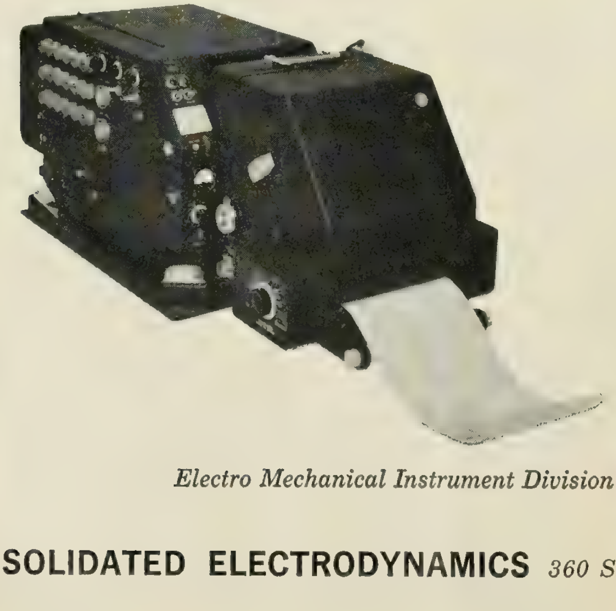


Here is the DATARITE Magazine many of you owners of CEC's 5-114 Recording Oscillograph have been waiting for: The new 5-047. This DATARITE Magazine attaches directly to your 5-114. The result is a data-processing tool with all the capabilities needed for modern dynamic tests—especially attractive for low-budget programs.

RAPID-ACCESS . . . THE 5-047 DATARITE Magazine provides the shortest access time of any known process, and yields records of high trace contrast and permanency. The Magazine automatically develops and dries oscillograms as quickly as data are recorded. Ready-to-read test results are available almost simultaneously with the occurrence of events under study.

The 5-047 recording speeds are variable from .45 to 28.8 ips. Fully developed and visible record is available in 0.7 second at 28.8 ips record speed. There is a generous capacity of 400 feet of conventional thin-base recording paper, combined with writing speeds up to 20,000 ips. Power requirement is 115 v, 60 cps, 1500 watts for the combination of the 5-047 and the 5-114.

For complete details call your nearest CEC sales and service office, or write for Bulletin CEC 1500-X24.



Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS *360 Sierra Madre Villa, Pasadena, California*

Washington Countdown

IN THE PENTAGON

Ultimate fate of ABMA . . .
remains decidedly unclear in the wake of recent Pentagon space juggling. Both NASA and the Air Force are considered likely inheritors of the Army space agency.

• • •

***Saturn* is a prime target . . .**
incidentally, of Administration budget cutters. The 1.5-million-pound-thrust clustered booster being developed at ABMA may turn out to be one the so-called "marginal" programs killed to keep the defense budget under the $40 billion annual ceiling.

• • •

Missile-lift by blimp . . .
may play a big role in the Space Age. Missilemen are considering proposals by **Goodyear** to transport the big boosters of today and the much bigger ones of tomorrow by non-rigid airships.

• • •

The Space project graveyard . . .
has new occupant—at least for the present. It's ARPA's *Project Suzano*—a space station study program. It hasn't a dime to work with and apparently no prospects of getting one in the budget-tight times ahead.

• • •

First test *Courier* . . .
communications satellite is presently scheduled to be launched next spring—probably about May. *Courier,* a delayed repeater satellite, is also the first of a series of communications satellites under development by ARPA and the Army.

• • •

First operational *Transit* . . .
navigation satellite is still scheduled to be in orbit by late 1961 or early 1962. The schedule is being held to despite the failure of the first test launching last month.

ON CAPITOL HILL

A full investigation . . .
of NASA contracting operations may be on the House Space Committee's calendar next year. The committee is particularly interested in NASA's $102-million contract with **Rocketdyne** for development of a single chamber 1.5-million pound thrust engine.

• • •

Some between-the-sessions . . .
inquiries by the House Space Committee also may be in the works for later this fall. One would involve patents on missile and space vehicle components.

• • •

Secretary of Science proposals . . .
appear to be picking up some new congressional support. Growing interest in the plan to create a Cabinet-level Science Department stems directly from the success of *Lunik II.*

AT NASA

The second *Big Joe* . . .
test has been cancelled because NASA *Project Mercury* engineers learned all they need to know from the first test. Though the *Atlas* booster failed to function properly, the capsule performed perfectly and a high enough velocity was attained to test re-entry.

• • •

The NASA budget request . . .
for FY 1961 may exceed $700 million. However, whether NASA can get that much from the Budget Bureau remains to be seen.

• • •

Test *Scout* No. 1 . . .
is scheduled to be launched late this year. The **Chance Vought** satellite booster is expected to be operational sometime next summer. It will be capable of putting 300-pound satellites into 200-mile orbits.

AROUND TOWN

Some of the reports . . .
being passed as "the latest" in the nation's capital:

. . . Deputy Defense Secretary Thomas Gates is considered the most likely successor to Defense Secretary Neil McElroy.

. . . More significant cuts and stretchouts in many defense programs are expected this fall and winter.

. . . *Project Mercury* costs in many cases are running 10 times higher than expected.

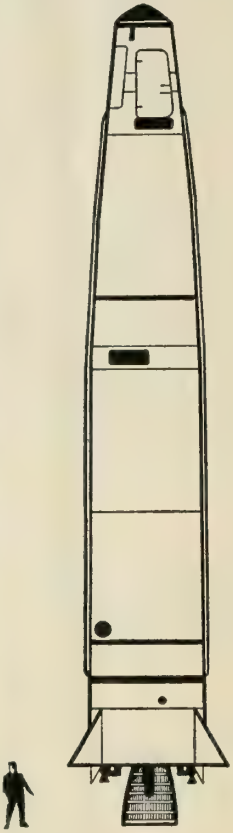
SAC INTERMEDIATE RANGE BALLISTIC MISSILE

The man:

. . . a launch-control specialist in a *Thor* SAC squadron. His instruments report each automatic step in the launching procedure of the big IRBM. U.S. Air Force and Royal Air Force missilemen are receiving *Thor* training side-by-side . . . have readied and fired these missiles within a 20-minute count-down.

The missions:

. . . are many—because of the Douglas *Thor's* versatility. As a highly mobile weapon with atomic capability, it sternly warns potential enemies against aggression. As a powerful and reliable booster, it is playing a leading role in our exploration of outer space with satellites and probes.



The missile:

. . . can destroy targets as far as 1500 miles away within minutes after hostile action is detected. Douglas *Thor* missiles were the first intermediate range ballistic missiles to be deployed overseas. The United Kingdom has announced the delivery of the first *Thors*, for operation by Royal Air Force personnel.

Depend on **DOUGLAS**

The Nation's Partner in Defense

Industry Countdown

MANUFACTURING

Automet is a brand new . . .

Army missile system under development by ABMA. The highly secret weapon reportedly is solid-fueled and is in the test vehicle stage.

• • •

ICBM mobility . . .

proponents are proposing a railroad launching system for *Atlas* and *Titan.* They believe Soviet guidance—as evidenced in the moon hit—has made it highly inadvisable to stick to the fixed-base concept until *Minuteman* comes along. Studies have been run showing it is possible to shoot either an *Atlas* or a *Titan* from a train—despite the liquid fueling problems. The chief obstacle is cost: much higher than *Minuteman.*

• • •

High BMD officials . . .

now are in the process of evaluating competing missile train systems designed by two teams—**American Machine & Foundry** and **ACF Industries** and **Paul Hardeman Inc.** and **Bethlehem Steel.** A contract may be awarded before the year is out.

• • •

Production run of combat . . .

Boeing *Minuteman* ICBM's will be 805, according to latest word around Washington. This would be sharp reduction in the 2600 originally planned.

• • •

Recruiting engineering talent . . .

is still a big business. One major advertising agency now has seven fulltime employes running a $1-million campaign just for one manufacturing client. Another New York agency with multimillion-dollar billings is devoted exclusively to recruiting and researching ways to keep high-priced scientific personnel.

• • •

Steel pinch . . .

is being felt by missile makers as a result of the steel strike. Pentagon sources say "minor slippages" have occurred in deliveries for missile subsystems and for rocket cases and pressure vessels. So far, however, no serious shortages have developed.

PROPULSION

Consumable solid rocket . . .

case is a new wrinkle proposed for weather soundings over populated areas. **Thiokol-Utah** is working on a plastic case with an oxidizer-resin mix that will burn with the solid fuel.

• • •

For purists . . .

the Air Force is insisting that liquid oxygen should not be called "LOX." The proper name: LOTWO (LO_2).

• • •

Eagle engine . . .

will be developed by **Aerojet General Corp.** under an $8 million contract from **Grumman Aircraft Engineering Corp.** The propulsion unit for the Navy air-to-air missile reportedly will utilize a high-performance solid fuel.

ASTRIONICS

Instantaneous ICBM . . .

launching from a train (or other mobile system on land) is now possible through a variation of SINS (ships inertial navigation system) developed for *Polaris* submarines. TINS navigation device would eliminate the need for trains to line up at benchmarks in order to program targeting data.

WE HEAR THAT—

American Machine & Foundry . . .

is in the market to acquire two electronic companies—one for computation and data processing and the other for guidance systems . . . German spaceman Dr. Walter Dornberger (*Dyna-Soar*) may leave **Bell Aircraft** for an important Washington job . . . **Union Carbide's Linde Co. Division** is building a liquid oxygen and nitrogen (135 T/D) plant near the missile facility at Fort Crowder Reservation, Neosho, Mo. . . . *Blue Water* is the code name for the new **English Electric** solid-fueled surface-to-surface tactical missile being developed for the British Army.

More About the Missile Week on Page 39

Now SAC's B-52G has a pair of hard-running teammates... the GAM-77 Hound Dog air-to-surface missiles. They can lunge into action at supersonic speeds to clear a path for the bomber by knocking out ground-defense centers hundreds of miles away. A pair of Hound Dogs carried under the wings of the Boeing B-52 increases the bomber's striking power ... gives it a triple-punch capability. Successful test launches of the jet-powered missiles are being made on schedule over the Atlantic missile range. The system will be deployed by 1960 under the present accelerated development program.

The Missile Division of North American Aviation is weapon system contractor for the GAM-77.

MISSILE DIVISION

NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

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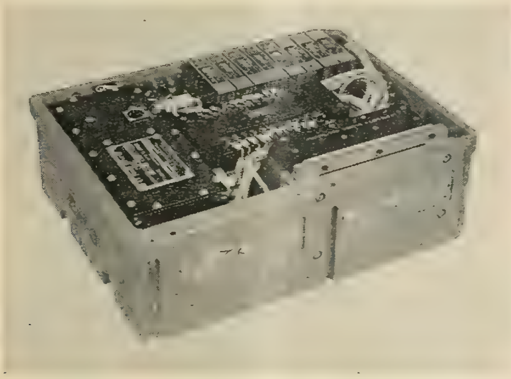
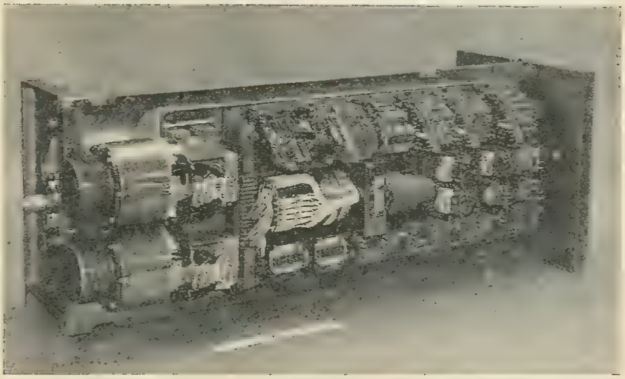
What's Wrong in Telemetry?

Lack of unity and realistic standards have hampered progress in a field vital to development of missiles; but something is being done about it



TELE-DYNAMICS system for *Bomarc B* uses ruggedized modular construction. The firm, a pioneer in the field, makes FM, PAM and PDM systems.



BENDIX ICBM telemeter weighs less than 90 pounds with power supply and transmits 172 information channels. The transmitter's power is 100 watts. Bendix turns out PM, PDM, is developing PCM.

by Hal Gettings

WASHINGTON—Lack of coordination and poor organization between missile makers, instrumentation manufacturers and the government/contractor-operated missile test ranges are impeding progress of the nation's blossoming telemetry industry.

And many in the industry feel that things will not be better until a joint industry-government group is formed to bring unity and understanding among the three principals. Such a group is now being formed—and is getting mostly unqualified endorsement.

The absence, to date, of such a group points up one of the main problems of this vital aspect of the missile and space program. Technologically, telemetry has made significant—if not completely satisfactory—progress. But, as in other fields, the pattern has been too much time and effort wasted because of poor organization and coordination.

Here's the rub: Instrumentation manufacturers find it hard to build the proper equipment to hazy and often unrealistic specifications. Missile makers don't know the capability and limitations of instrumentation. And the missile ranges don't know test requirements far enough ahead to plan and budget for equipment installation.

Boiled down, it simply means that one doesn't always know what either of the other two is doing.

• **Dearth of data**—A good example is the fact that Electronic Industries Association, usually considered an objective authority on all matters electronic, doesn't even have a classification relating to missile telemetry. And the National Security Industrial Association does not, to date, have a committee assigned to this field.

There's no information on exactly how big and important the business is. Estimates range from $120 to $250 million annually, with the expectation that the next 10 years will see double the present volume. Figures are hard to break down and separate, however; telemetry laps over into control and guidance, and there is a question as to just where data reduction and computation begin and end.

No one questions the importance of telemetry in its relation to the development of successful operational missiles and space vehicles. A flight system may have any number of experimental components or subsystems, but never may it have experimental telemetry. Missiles aren't fired to test the telemetry, but a proven reliable telemeter must be aboard every missile if its performance is to be measured and evaluated.

Progress in this field calls for continuous research and development independent of specific flight systems. New materials and subsystems must be developed, exhaustively tested, and integrated into telemetry designs. Designs must be service-tested and proven before incorporation into flight systems.

• **Who's in the business**—Telemetering systems manufacturers are few. Probably the leader in the field is **Radiation, Inc.,** with the bulk of its $13-million annual volume in telemetry and associated areas. They have pioneered in digital systems and automatic data processing. Radiation recently received contracts totalling around $6 million for the **Boeing** *Minuteman* PCM telemetry. Details of this equipment are not yet available, but it is reported to be the most advanced and complete system yet developed.

Epsco, Inc. has done considerable significant work in digital telemetry and data conversion, with an annual volume of approximately $2½ million. One 10-bit PCM system just delivered handles up to 25,000 samples per second with an accuracy of 0.05%. Epsco also builds 17-bit equipment.

Bendix-Pacific has built an outstanding capability in both systems and components. They have produced FM and PDM equipment and have PCM under development.

Tele-Dynamics, Inc. is one of the pioneers in telemetry. They claim to be the only firm offering a complete system including the radio link. Their equipment embraces FM, PAM, and PDM systems and components.

Ralph M. Parsons does extensive system and feasibility studies for range instrumentation. They are the largest producer of FM decommutation equipment and also turn out transmitters and data converters. They built FM and PDM systems for the *Bomarc* and outfitted the Atlantic Missile Range picket ships.

Other systems manufacturers include **United Electrodynamics, Lockheed, Space Electronics, Applied Science Corp. of Princeton, Philco,** and **Melpar.**

Component and equipment makers include **Dynatronics, Telechrome, General Electronic Laboratories, Nems-Clarke, Advanced Electronics, Hallamore, Rheem, Centronix, Hoover Electronics, Packard Bell, Consolidated Electrodynamics Corp., Electro-Mechanical Research,** and **Telemetering Corp.**

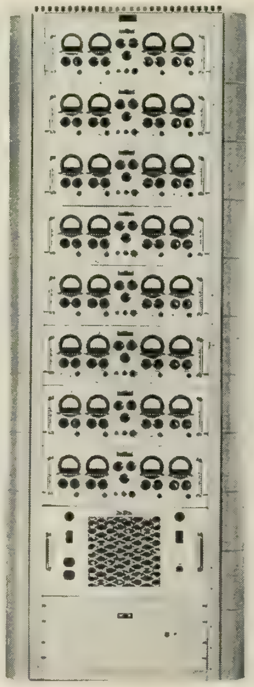
- **Frequency allocation**—Restricted band widths allocated to telemetry use have been a constant source of problems. The 225-260 mc band has been assigned for use until 1970, and after that on a non-interference basis. This band has holes in it, however, and the proximity of high-powered radar brings complications.

The higher frequencies becoming available have their problems, too, and there's an urgent need for extensive R&D to provide equipment for these bands. Transmitter efficiency at these frequencies is relatively low; compromises will be necessary to balance increased information-handling capability against reduced electrical efficiency. A new heterodyne technique, permitting superposition of several standard analog multiplexes and simultaneous transmission of very-high-frequency data over a single r-f channel, may make it possible to cut overall system size and weight.

If telemetry engineers had their "druthers," they probably would prefer frequencies in the 400-500 mc band. Under present assignments, however, it is extremely doubtful that anything in this area will ever be available. If enough R&D effort is brought to bear on the problem, future telemetering frequencies probably will be in the kilomegacycle bands.

- **Analog vs. digital**—Frequency-division multiplex systems have, until recently, been the only type of practical telemetry used. FM/FM, of course, remains the primary technique and probably will be for some time to come. Others—PDM, PPM, PAM—are also used extensively.

In spite of its shortcomings, many factors argue for continuing use of FM. Primary is the fact that practically all ranges are set up to handle FM information—and the facilities investment is tremendous. Too, where continuous data is required, only analog information will suffice.



NEMS-CLARKE Diversity Combiner/Adder blends outputs of up to four receivers connected to different antennas and gets a single, high-quality signal.

Like the farmer who wasn't farming half as well as he knew how, FM telemetry is potentially much better than its present operations might indicate. Some advances have been made toward greater efficiency and further developments are being studied. The problems of noise and distortion are inherent in the system, however, and every step in analog data handling—from pickup to reduction—is subject to cumulative inaccuracies.

- **Digital techniques**—Practical digital systems have been built only recently. They offer considerable advantages—in speed, accuracy, capacity and reduction facility—but also problems. Power and space requirements are much greater than for a corresponding analog system; much work must be done to improve stability, size, and reliability of the airborne coders and multiplexers. In general, however, many feel that the problems of pulse-code modulation will be solved and it will pretty well dominate future telemetry.

- **Compatible systems**—The advantages of analog and digital systems have already been combined with some success. The addition of compatible digital equipment to existing analog systems can provide improved data acquisition, processing, and control subsystems at a fraction of the cost of total system replacement. As an interim measure, a compatible system offers versatility, accuracy, bandwidth utilization efficiency, and improved signal-to-noise ratio.

Future Developments

Microminiaturization promises much for the future of telemetry. When we can produce stable and reliable ultra-small components and circuits, we will have removed the primary objection to airborne digital equipment. But, although some equipment of this type has been used, practical systems are still some years away.

- **Digital transducers**—The advantages of direct digital output from information pickups are readily apparent. The problems involved are tremendous, however, and no significant breakthroughs are within sight. Several companies are researching this area on a small scale, but no more than nominal progress is expected.

- **Magnetic amplifiers**—Although they are getting little attention from instrumentation manufacturers, magamps have considerable promise for telemetry. They are now being made much lighter and provide much faster response than generally supposed. Recent investigations have shown that critical selection of core material can lead to efficient, highly reliable amplifiers.

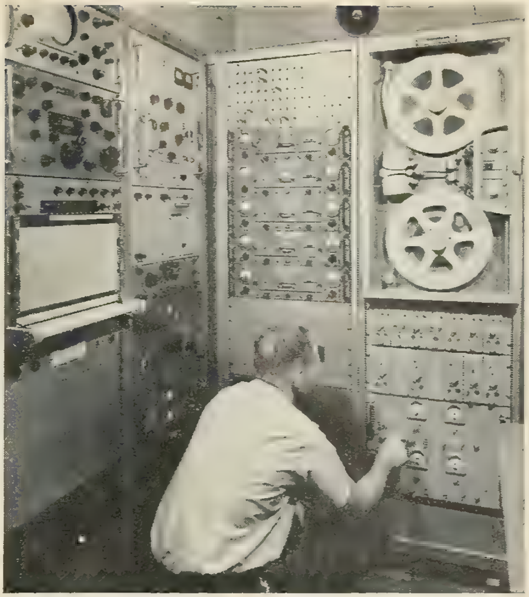
- **Transient measurement**—Much needs to be learned of the effect of transients on missiles—temperature, shock, etc. This can be investigated only with better telemetry than is now available. Consequently, better transducers and components with extremely high response must be developed. A further complication is that little is known about the effect of transients on the transducers.
- **Sophisticated systems**—Telemetry eventually will profit greatly from development of more sophisticated systems. Although the ultimate in sophistication is a long way off, and perhaps will never be attained, research into more intelligent systems is expected to yield dividends in bandwidth conservation, accuracy, and reduction capacity.

Ideally, a telemetry system would reject static and irrelevant data and select and transmit only pertinent information. It would include its own calibrator, and filter out incorrect data. It would be able to program and superimpose channels to use only minimum bandwidth.

Probably the first evidence of more refined and advanced techniques will be in the form of more sophisticated code forms and in autocorrelation and cross-correlation. These must be perfected in the near future.

- **Diversity techniques**—Some research has gone into the advantages of diversity techniques for improving telemetering transmission. One study by Parsons showed that both space and polarization diversity would be practical and helpful. Frequency diversity was also shown to be desirable but not practical—due to bandwidth requirements.
- **Data reduction**—Laborious and inaccurate manual reduction of analog data has been a major log jam in missile test evaluation. Considerable money and research has gone into eliminating this deficiency and several improvements have evolved in recent years. Actually, ground data processing has already progressed beyond other aspects of telemetry. Innovations have been accepted much faster, since a failure in this equipment does not result in a permanent data loss. Extensive R&D in the telemetering link is required to catch up.

One advantage of digital data, of course, is that it lends itself easily to fast, automatic, and accurate reduction. Straight digital systems incorporate this feature. In addition, several new systems have been developed to convert received analog data to digital format for ease in processing.



BANK OF high-precision equipment lines one of two windowless trailers which give ABMA a mobile means of testing instrumentation designed to telemeter information from satellites.

The first of these was one developed for Project *Vanguard* by NRL and Radiation, Inc. Others have followed; several of varying capability are in service today.

The Royal Canadian Air Force has just installed what it calls "one of the world's most efficient missile testing systems" at its Cold Lake, Alberta, rocket range. This equipment collects three different forms of analog data and reduces it, in real time, to a BCD format for digital computer entry. It handles 53 channels and reportedly can process data from an entire test flight within 16 hours. Previous manual-reduction methods required 3200 man-hours.

- **Data display**—The visual display of telemetered data is especially important in rapid evaluation and reduction. During the missile flight, real-time displays are important to monitoring personnel; during data analysis, time and effort and computer use can be saved by editing raw data before reduction.

Much progress has been made, particularly in the digital systems. Real-time quick-look, with both digital annotation and discrete-level analog plots, is provided in several systems. High-speed x-y plotters, also using the multistylus technique, are being developed. Lockheed only recently announced completion of one new plotter, used in the *Discoverer* and *Polaris* programs, that is 17 times faster and 12 times cheaper than old methods.

Meeting the Challenge

Progress is being made in many different aspects of telemetry. Although many feel that overall progress is too slow, strides have been made clearly suggesting that telemetry may be equal to its future missions.

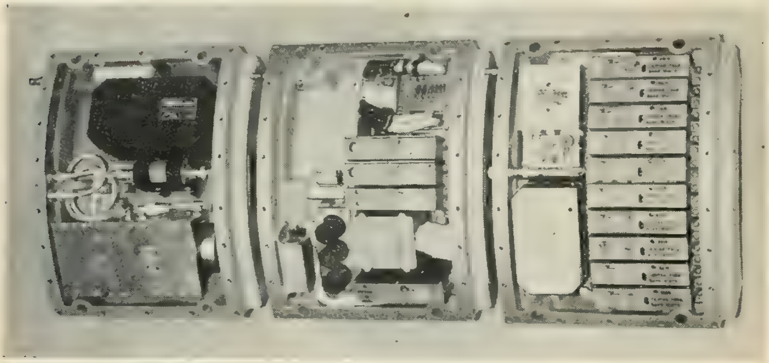
- **Direct re-entry telemetry (DRET)**—**Avco Corp.** scientists have reportedly broken the previously impenetrable barrier of the ionized layer surrounding a re-entry body. Using an unspecified UHF band, they reported feasibility of direct re-entry telemetry last May. Such a technique would allow continuous real-time transmission—as well as communications—during the entire transititional phase of a flight from outer space to earth. Details of the technique are classified.

DRET would be invaluable in re-entry vehicle tests and have wide application in such programs as *Mercury* and *Dyna-Soar*. Presently, it is necessary to record data during the re-entry phase and then transmit it in the few seconds left before impact—or hope to recover the vehicle and recordings intact.

- **Pulse-code modulation**—The use of PCM has advanced considerably during the last year. The "Digilock" system developed by **Space Electronics** (M/R, June 13) is the first "orthogonal" type to appear. It has many of the advantages of pure digital, but eliminates some of its disadvantages. Digilock approaches the maximum communication efficiency possible under information theory and incorporates both variable accuracy and variable data rate. With its maximum data rates, one system can provide information bandwidth equivalent to several FM/FM systems.

General Electric has developed a PCM/PS (phase-shift) system which

capacity for progress demonstrated . . .

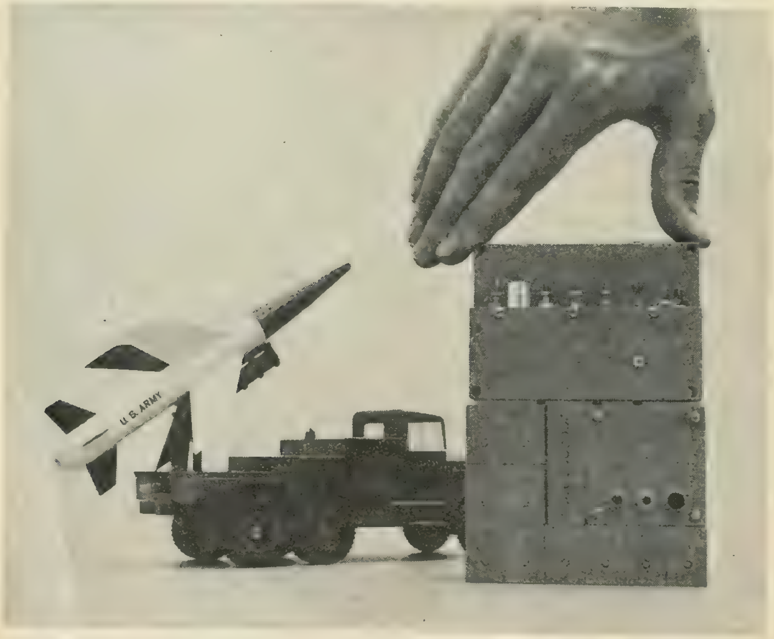


TELEMETER for the Navy's Bendix *Talos* provides 45 information channels. Except for a 14-watt transmitter, the unit is completely transistorized.

uses correlation detection and a novel redundancy coding technique. Transmitter power required is equal to or less than that of an ideal PCM-FM system. Use of a synchronous receiver permits r-f detection at S/N ratios less than –8 db.

- **Delta modulation**—Sometimes called "the poor man's PCM," delta modulation was the subject of a recent study program at the University of British Columbia. The system is simple and cheap and has many of the advantages of pulse-code techniques. It works by a feedback loop which compares an instantaneous measurement with its simultaneous integrated value —hence the name "delta." Its big advantage is that it makes it possible to lose a pulse without disturbing the code sequence.

- **Frequency modulation**—Competition with other systems has brought a growing awareness that FM components and techniques could well be improved. Research has already yielded some concrete results and more are anticipated.



MARTIN'S subminiaturized *Lacrosse* FM/FM telemeter transmits ten channels of go/no-go data for the highly accurate surface-to-surface missile.

In the area of telemetering receivers, substantial progress has been made (M/R, Aug. 24). The incorporation of phase-lock predetection recording, and parametric amplifiers are especially noteworthy.

Hoover Electronics has introduced a new development, called "Vernitel," which, it claims, upgrades FM system accuracy by a factor of ten—to a point comparable with PCM—without requiring additional bandwidth. The unit contains a quantizer which separates information voltage into a coarse voltage of 16 discrete levels and a vernier, or residue, voltage. Each of these voltages controls a standard FM subcarrier oscillator.

A diversity combiner/adder produced by **Nems-Clarke** operates to improve the quality of received signals. This unit—considerably more than a comparator—combines and adds up to four inputs and produces an output signal stronger than any of the separate inputs. It can be used with different antennas for polarization or space diversity or—with synchronization circuitry—for true frequency diversity.

ASCOP recently developed relatively sophisticated equipment which analyzes data before transmission to the ground (M/R, Dec. 1, 1958). Its principal advantages are savings in space, weight, and bandwidth. Using three units—spectrum analyzer, amplitude probability analyzer, and a time-of-occurrence marker—it statistically analyzes collected data and extracts its significant information content for transmission, recording, and evaluation.

"Telebit," **Space Technology Lab's** telemetering system for *Explorer VI* (NASA's "paddlewheel satellite"), is the most advanced flying today. This tiny system is designed to transmit data over interplanetary distances up to fifty megamiles. It contains a computer which adds and calculates collected data, stores it, and then transmits it to earth at programmed intervals.

Further improvements in oscillators, discriminators, transmitters, and receivers promise to enhance the quality and prolong the usefuless of FM telemetry. Better calibration and operation techniques—and better training of operating and maintenance technicians—are prime areas for future effort.

The capacity for progress has been demonstrated. If this progress can be coordinated and realistic standards can be formulated and adhered to—and if proper attention is given to further research and development—telemetry will overcome its existing deficiencies and take its rightful place in the forefront of missile development.

Data Handling System May Increase Use of Digital Tape Recording

This 100-lb. tape recorder with a total capacity of 2,400,000,000 information bits is touted as having great potential for future space exploration

PASADENA, CALIF.—The successful performance of high-density pulse-packing techniques in a new airborne magnetic tape recorder points to greater use of digital recording aboard future missiles and planes.

The equipment, with unprecedented pulse-packing capability, was developed by the **Datalab Division** of **Consolidated Electrodynamics Corp.** and **Douglas Aircraft Co., Inc.,** for an automatic data handling system used in flight testing.

Weighing only 100 pounds, it has a capacity of 1500 bits per inch on each of 16 tracks along its one-inch tape—providing a total of 2.4 billion bits.

• **Initial requirements**—High-density recording was demanded by the flight testing system for which the recorded was first developed. Douglas wanted an airborne system that would sample 100 primary channels each at a frequency response of 100 cps. Also, the system had to be able to record an hour's test time, and its size and weight had to be minimal.

In common practice, it takes five samples to reproduce a sine wave. If the system must accommodate sine waves from 100 channels, each at 100 cps, the recorder must have the capacity for 5x100x100 samples per second, or a total of 50,000 samples per second. To make possible an hour's recording at this sampling rate on a 14-inch reel of magnetic tape, required a technological breakthrough in pulse packing.

Finally, Douglas chose PCM telemetry; the recording equipment had to be compatible with the system.

TAPE RECORDER stores 1500 bits per inch on each of 16 tracks. Note flangeless reels. Overall dimensions are 6⅜ by 18 by 26 inches.

• **PCM telemetry**—This telemetry mode was selected for several reasons. It is most accurate. It is less susceptible to distortion by noise than other transport speed. Datalab engineers say this will be important in future space exploration because it makes it possible to restransmit from relay stations without distortion.

Accuracy will not deteriorate over long transmission and, if secrecy is necessary, PCM can be enciphered. Also, digital data can be conveniently introduced into computers for quick computation of results.

• **Disadvantages solved**—Previously, there were several disadvantages in digital recording. Tape economy was poor. And tape skewing can cause serious error because the bits making up a data word are recorded parallel across the tape. When played back, serious skewing will cause bits in adjacent words to mix.

The first disadvantage, poor tape economy, was answered by the system's unprecedented pulse-packing capabilities. To produce a reliable and accurate airborne recorder with high-density packing, engineers concentrated on three features: magnetic heads, tape guidance system and reeling system.

The most critical tolerance observed in fabrication of the magnetic heads were gap scatter (center-to-center spacing of the gaps measured in the direction of tape motion) and base squareness.

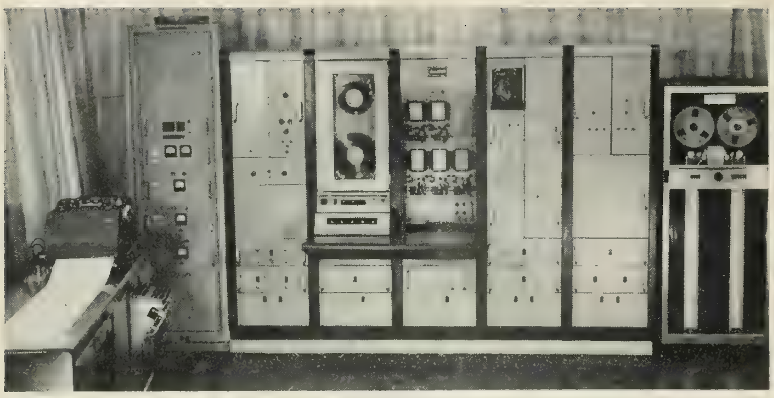
The system records 11-bit binary coded words representing a number on a scale of amplitude from each point which data are acquired. All bits making up a single word are recorded simultaneously across the tape. With the aid of three clock tracks, these are later played back on a ground station reproducer. Sequence of playback must coincide with the record sequence, and, because of the high density of signal packing, this requires adherence to close tolerances. Gap-scatter tolerance and maximum tilt are 0.0001 inch. These tolerances are checked by optical and electronic devices.

The record head has a low inductance center-tapped winding, permitting it to be driven with transistors. The playback head has a larger number of turns to increase amplitude during playback.

The physical composition of magnetic tape can cause its velocity to vary across the width when it travels across the magnetic heads, leading to misalignment of the recovered pulses. This "differential flutter" can also result from uneven drive across the tape width, inadequate guidance, or uneven tape edges. Conventional recorders frequently allow a 0.0003 inch displacement between outside tracks on a one-inch tape. This limits the packing density.

A solution was found by using a long bow-shaped chute with no moving parts to guide the tape across the magnetic head. Inner walls of this guide are flat to within 0.0005 inch. This simple but practical device reduced differential flutter to one-third that of conventional recorders.

For tape reeling, Datalab engineers



COMPUTER INPUT facility had editing facilities and IBM 727 tape transport (right) for providing tape compatible with IBM 704 computer.

developed a flangeless reeling mechanism that preserves the accuracy necessary to record and reproduce high-density signals, while at the same time reducing weight and space.

Without flanges, the reel hubs could be brought together to take advantage of the fact that the supply reel decreases in size as the takeup reel increases. This made possible a 3.5-inch reduction in the length of the recorder case, and an accompanying decrease in weight.

Precision reeling is brought about by accurate follower arms which guide the tape at its point of tangency to the reel. The squeegeeing action of the follower arm made it possible for 17% more tape to be contained in the same diameter reel because of more compact winding. Tape length is 8400 feet instead of 7200. The coil of tape proved firm enough to support itself during operation and handling.

To maintain the position of the tape on the hub during shock or acceleration, tapered guide rollers are placed above and below the supply and takeup reels. The rollers are mounted by low-friction ball bearings to prevent interference with tape travel under extreme environmental conditions of flight testing. In normal operation they do not touch the tape.

Constant tape speed is maintained by pinching the tape to a rotating capstan driven by a hysteresis-synchronous motor powered by a 400-cps precision frequency source. When the transport is energized to record, a tachometer senses tape speed as it builds up. When tape speed equals capstan speed the tachometer signals the pinch roller to pinch the tape to the capstan. Mechanical filtering eliminates flutter which might be transmitted by the drive belts.

Despite the diminishing radius of the supply reel and increasing radius of the takeup reel, constant tape tension is maintained to prevent stretching and distortion. The reel motor supplies the torque that pulls the tape. Cords of nylon with glass braid covering serve as clutches to control the position of each tape follower arm and to provide holdback torque for each reel in proportion to the radius of the reel.

The tape recorder system is mounted on a deeply ribbed casting of aluminum-magnesium-zinc alloy that is precision-machined for flatness. The ribs that provide chassis rigidity also serve as ducts which channel cooling air past all heat-producing components. By combining the functions of structural support and ducting, weight was again minimized. This approach to cooling also prevented dust, which might enter with cooling air, from getting into vital components. Air filters, which increase weight and decrease cooling efficiency, were eliminated.

• **Operation**—The airborne acquisition system is one of three separate but integrated groups of equipment comprising the Automatic Data Handling System. The others are a ground control and record station and computer input station.

The airborne system performs the duties of signal conditioning, calibration, amplification, multiplexing and analog-to-digital conversion. Signals are recorded on the tape recorder and simultaneously telemetered to the ground control and record station via PCM/FM.

Each of the 100 primary channels can be sampled at rates up to 500 times per second with errors not exceeding one part in 1000. Any primary channel in ratios of 10:1 and/or 100:1. As a result, a maximum capacity of 10,000 inputs, each sampled five times per second, is possible.

A bar chart display allows a pilot or flight engineer to monitor up to 100 channels of test data visually. This display consists of up to five rectangular cathode ray tubes displaying 20 channels each.

An operator control panel has facilities to initiate system calibration, to indicate elapsed time, to enter event marks on the tape, to change frame rate, to control the magnetic tape recorder and to control the electric power to the airborne system.

Airborne equipment is modular to allow easy changes in input configuration as flight test requirements change.

• **Station facilities**—The ground control and record station is housed in a 33-foot trailer. A 12-foot dish-type telemeter antenna and its rotating mechanism are mounted on a separate trailer, as is a power generator that allows the trailer to function independently.

This station receives telemetered signals from the airborne system and, after serial-to-parallel conversion, provides a separate magnetic tap record for back-up or rapid data processing, 100-channel bar chart display, time history plots of up to 20 channels, display of elapsed operating time, event mark indication, and a counter which indicates dropout and transmission errors. Two direct-writing oscillographs are located on special readout tables for convenience in viewing and analyzing the records.

The bar chart display, elapsed time indicator and voice communication equipment are located in a control console which serves as an observation and control center for the flight test. From here test engineers can guide the flight to a successful conclusion, rather than waiting for the data to be analyzed before determining success of a maneuver.

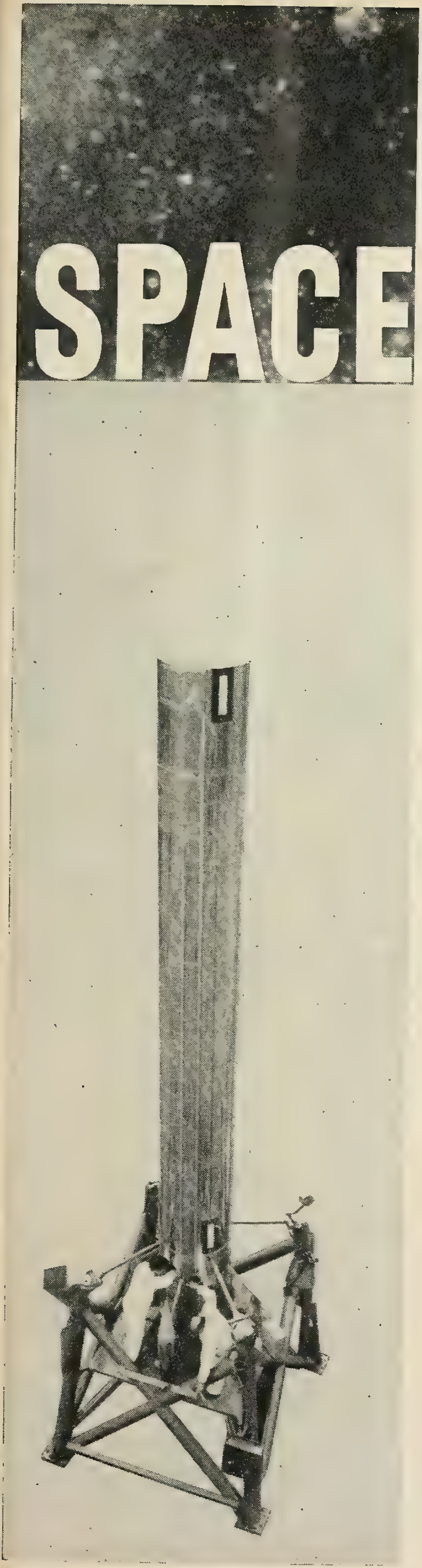
Magnetic tape recordings from either the airborne system or ground control and record station are played back by the computer input station, which has editing facilities for selecting only channels and frames of data that are essential for each particular computer program. This enables the most economical use of computer and personnel.

• **Data processing**—It is possible for test data to be processed and computations made available to development engineers before the flight of the vehicle under test is completed.

Five modes of editing are provided: flight-test data-tape search at high speed, time selection, channel selection, frame selection, and arbitrary selection of frames by the computer station operator for averaging methods. In addition, the system can be programmed to enter all calibration data into computer memory.

After editing, the desired data are entered into a magnetic-core storage unit which formats the data for recording on an IBM 727 tape transport. In turn, the IBM 727 recording introduces data into a 704 computer.

SPACE RESEARCH



BRISTOL SIDDELEY GAMMA ROCKET ENGINE POWERS BLACK KNIGHT-BRITAIN'S HIGHLY SUCCESSFUL SPACE RESEARCH VEHICLE

On 11th June, 19,000 lb of thrust sent Black Knight to the threshold of outer space—500 miles above the Woomera rocket range in Australia.

This was the third successful firing *(there have been no failures)* and much of the credit for Black Knight's trouble-free performance must be given to the Gamma.

The Bristol Siddeley Gamma 201 is a liquid propellant rocket engine. Four trunnion-mounted chambers burn kerosene with HTP and each chamber is fed by its own turbopump unit. The complete weight of the engine compartment is less than 700 lb (dry) and Gamma delivers 19,000 lb at altitude—16,400 lb at sea level.

Black Knight is a research vehicle and no military applications are planned. But the experience gained and lessons learned from this highly successful space probe will be invaluable in the development of Britain's IRBM—Blue Streak.

So impressive is Black Knight's performance with the Gamma powerplant that even more advanced applications are being actively developed. In fact, Black Knight coupled with Blue Streak is first choice to put Britain's projected space satellite into orbit.

BS

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Universal Checkout Center Is Urged To Match Weapon System Advances

Packard Bell, with experience in Polaris, Thor and Falcon programs, believes concept will reduce inventories and personnel and enhance portability

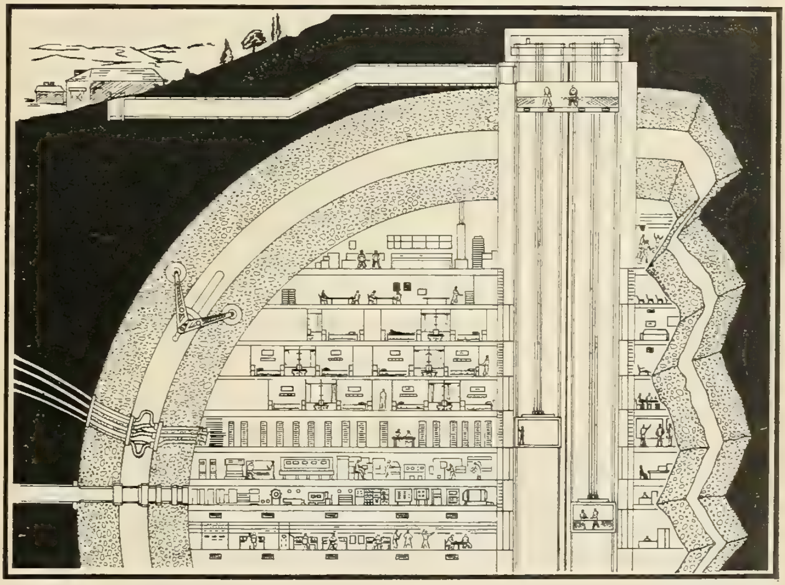
LOS ANGELES—A new concept—in many ways revolutionary—for a centrally located, universal test center has been proposed by **Packard Bell Electronics Corporation.** The idea is a byproduct of the company's extensive R&D efforts in automatic checkout equipment.

Packard Bell feels that the Space Age demands new concepts in support equipment to match the ever-increasing sophistication of weapon systems and space vehicles—and that the use of specialized electronic support equipment at each launching area or air base will soon become outmoded.

In place of vast quantities of duplicate equipment, one or more centralized control centers containing multipurpose support equipment and necessary elements of command could be established in emulation of the SAGE system.

From strategic sites, these test centers could remotely check out ready missiles, aircraft, or other weapon systems, validate their readiness or isolate areas where malfunctions exist, indicate their status to all appropriate commands, and release or hold the instrument of combat as indicated by test results.

Implementation of such a program, the company feels, will reduce manpower and material requirements, speed the reaction of the armed forces, and make it possible to include in all command decisions such factors as foreign policy, logistics and the overall tactical situation.



PROPOSED universal test center would be spherical concrete structure providing space for normal operation of computers, communications checkout, and missile command functions. Remotely operated TV cameras would supply surface observations.

• **The concept**—Packard Bell recognizes that some persons might consider the idea of a universal test center—possibly located in the geographical center of the United States—to be impracticable.

"The engineer and the scientist will think of the communication problems; the military man will think of jamming problems and loss of communication through enemy action; and the layman will consider the whole idea just another Utopian concept that may come to pass in the dim future," the company said. "But (the idea) seems a must, rather than a scientific extravagance."

• **Justification**—The company brings out these points: (1) It is apparent that the 1000-to-4000-aircraft raids of World War II will not occur again; (2) It is unlikely that any country again will overwhelm another by sheer strength of numbers because atomic and hydrogen bombs have dissipated this possibility and have left the U.S. with the firepower of 1000-to-4000-aircraft weapons concentrated in very small packages.

These facts justify establishment of a centralized test center, Packard Bell says, since the number of weapon systems with which communications must be set up is minimized; there will be comparatively few commands, and each will be capable of releasing many times the power of a 1000-plane raid with each of its systems.

both air and ground links . . .

As for responsibility, the company observes that: (1) Unleashing these "all-or-nothing" weapons, when required, will be a responsibility of the top command of the United States and will carry the policy stamp of the government; and (2) Although launch responsibility is a top-command decision, determination of weapon operational readiness is today a matter of decision for local commanders, whose decisions may be subjectively biased by local conditions or the pressure of time; and (3) It is apparent that the determination of readiness is misplaced at the local level because the determination that a hydrogen bomb carrier, with its potentiality of a million mortalities, is ready to be launched is not a local command decision any more than its launching.

• **Area of decision**—The company said that it appears that determination of armed readiness must be made in a central area where the leaders of industry and government have the facts for an instantaneous pre-evaluated solution. "Only in an atmosphere where emotional details are eliminated and scientific logic is substituted can this determination be made."

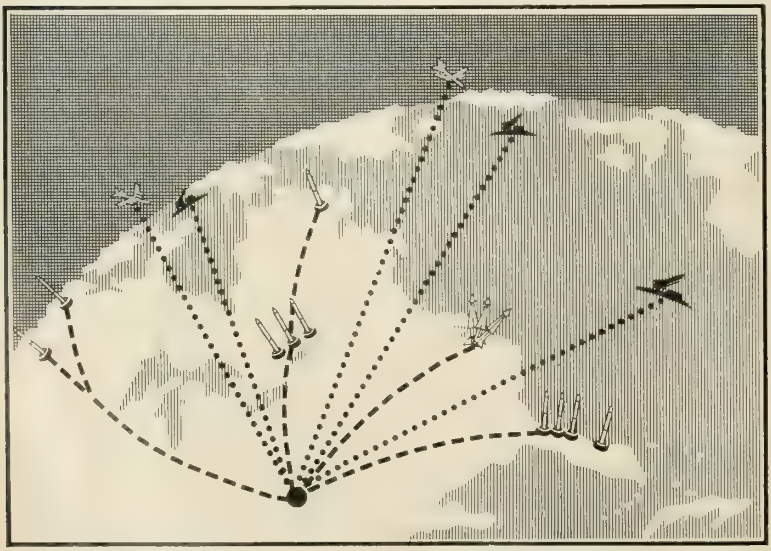
The universal test center, containing general-purpose computers, armed forces command elements, and direct communication with all field elements, affords such an environment, the company believes.

• **Link between systems**—Connection of the centralized test center to its weapon systems will be a basic problem. One of two methods may be employed to establish a connection between any checkout system and any weapon system. These are the direct connection by a cable and the indirect connection by an air link.

Today's weapon system developments deal almost exclusively with the immediate problem of providing a necessary functional connection between weapon system and checkout system. Sophistication in this area is neither sought nor desired.

For instance, designers of electronic equipment normally desire a large number of test points to ensure the highest possible certainty of weapon readiness. The airframe designer, on the other hand, is reluctant to supply excessive wire runs due to the weight penalties incurred. These two desires naturally conflict and can only be compromised in a manner which does not precisely satisfy either engineering requirement. The linking method for the remote, centralized test center will have to be one that imposes a minimum of weight penalties and yet makes possible the necessary degree of weapon readiness assurance.

Cable connection via a direct cable to the weapon system has several advantages, the company feels. Electrical interference in jamming is minimized, test signals enter directly and are not unduly attenuated, and a larger quantity of tests per equipment can be made.



MAP SHOWS how centralized test center would have ground connections via cable and air links radiating to radar observation points, planes, missiles and warships.

But Packard Bell pointed out that air-link checking, on the other hand, has the advantage of requiring no physical contact with the aircraft or missile and allows the test to proceed while the instrument of combat is in motion. Each of the methods is supreme in one area. Air-link checking, for instance, is not feasible at production-line centers where cable connections can readily be made. By the same token, tests can be made during turnaround periods via an air link more quickly than by any other method.

For the test center, an air link, suitably coded in the manner employed by present-day IFF equipments, could be used along with a ground line for parity checks or for redundant information.

• **State of the art**—Many of the weapon systems now coming into being utilize some form of centralized checking. In these systems a special-purpose computer is connected to test areas within approximately a half-mile and is used in much the same way as a remote test center.

The only difference between a completely universal remote test center and these present concepts, the company feels, is distance. "It seems evident that if a signal- and power-carrying line can be run for a half-mile it might also be extended to several hundred or several thousand miles and obtain the same functional capability."

• **Advantages of center**—The greatest advantage of the centralized test center, according to Packard Bell, may be the portability allowed for the weapon system. With suitable test-center repeater stations in operation, weapon systems might be operated at an instant's notice from any locality in the world. The black-box testers and associated test trailers, along with a host of skilled maintenance personnel, could be reduced to a minimum.

A weapon system might move as the tactical situation dictates, rather than as a function of logistics or local support capability, the company adds. With logistics problems minimized, military commanders would be able to make military moves unbiased by the considerations which have compromised past and present tactics.

The practicality of a test center presupposes some form of universal tester which may be applied to many weapon systems. If this test system were to be merely a composite of all present systems, the quantity of equipment would be impossible to house. However, a vast majority of these test systems can be eliminated because of the similarity of inputs and outputs. These consist of such factors as voltage, impedance, current, radiated power, frequency, and mechanical motion.

The company feels that a multipurpose system which will support many systems can be designed and made considerably smaller than the sum of test equipment used by these weapon systems individually. Such systems are available even today and have demonstrated their usefulness in the present generation of missiles. The armed forces are investigating the optimum combinations of units in multipurpose equipment available at this time.

Not least among the prime advantages of a centralized test center is the consideration of cost. With cost and manpower requirements increasing at an expanded rate with the sophistication of weapon systems, a point is being reached where the law of diminishing returns will take full effect.

For instance, in missile weapon systems, approximately 80% of the weapon system is composed of support elements or checkout equipment. This means, for a given amount of increase in weapon system dollars, only a 20% increase in weapon-system capability is obtained.

Packard Bell says that implementation of a centralized test center will appreciably reduce the $100 billion in military electronic inventories and cut the number of personnel (approximatly one million) employed to service this inventory.

- **Studies continuing**—Studies made by the company over the past two years are being continued as "advanced-development" efforts. In the meantime, the company says literature on present checkout equipments indicates that a centralized test center as has been described is feasible and necessary. It is eminently practical, Packard Bell spokesmen declare; it is less costly than present practices, and it coordinates the channels of command as the situation indicates.

Since each of the armed forces has its own particular checkout problems and checkout philosophies, it would appear that a joint effort should be made among the Army, Navy, and Air Force to implement such a design and to consider it for simultaneous use. In this way manpower and dollars could be expended for maximum efficiency and the betterment of each service's weapons.

The horse-and-buggy days of a one-to-one relationship between testers and equipments has passed. The pressure of world circumstances and the advance of science exert an inexorable pressure in the direction of a centralized control area.

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IN A SPECIAL KIND OF WORK

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Cabin Conditioning System Weighed

British researchers find air-purifying, oxygen-replenishing system for a man would weigh 55 lbs. for 2 days, 235 lbs. for 10 days

LONDON—Cabin conditioning equipment for a satellite manned by one Astronaut might weigh from 55 to 235 pounds, for a flight ranging from two to 10 days.

This conclusion was reached by George Beardshall and Peter W. Fitt of **Normalair Ltd.**, Yeovil, in a paper given at the British Space Flight Symposium.

Beardshall and Fitt outlined conditioning systems designed to maintain temperature at about 68°F, oxygen between 20% and 60%, humidity below 10 mm Hg, and CO_2 below 7 mm Hg. At an average human metabolic rate of 400 BTU/hr., they assume oxygen intake of 0.105 lbs./hr., carbon dioxide output of 0.125 lbs./hr. and water output of 0.16 lbs./hr. They set figures a little high because of the sketchy knowledge of physical reactions—including excitement—to weightlessness.

Evaporation was rejected as a method of cooling because this would result in overboard ejection of mass that must be in the vehicle as extra weight at takeoff. Instead, it was assumed that the vehicle will be designed to have a passenger cabin as completely leakproof as possible.

Temperature control would instead be largely based on reflection and absorption of solar radiation, through the choice of external finish and construction—a method already proved partly successful in the smaller unmanned satellites.

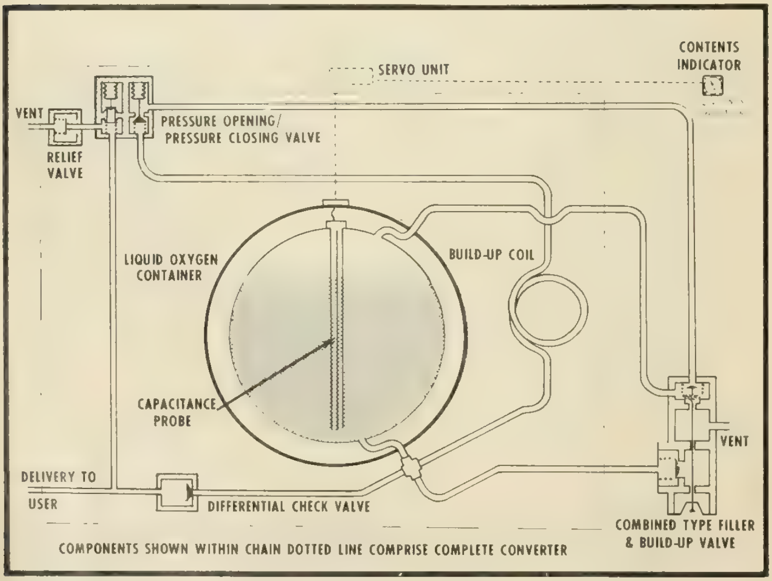

CONTENTS INDICATOR
SERVO UNIT
VENT
RELIEF VALVE
PRESSURE OPENING/ PRESSURE CLOSING VALVE
LIQUID OXYGEN CONTAINER
BUILD-UP COIL
CAPACITANCE PROBE
VENT
DELIVERY TO USER
DIFFERENTIAL CHECK VALVE
COMBINED TYPE FILLER & BUILD-UP VALVE
COMPONENTS SHOWN WITHIN CHAIN DOTTED LINE COMPRISE COMPLETE CONVERTER

FIG. 1—Liquid oxygen provides a supply of life-giving atmosphere for Astronauts. Continuous introduction of heat boils the liquid steadily until pressure above the fluid closes the cutoff valves.

Since the Astronauts may have to enter the craft as much as eight hours before takeoff, a ventilation system must be provided to avoid unnecessary consumption and use of the cabin conditioning before takeoff. This could be done by an external ventilation source that would be disconnected during final phases of countdown. Slight pressurization would make possible last-minute leak tests.

• **Maintaining pressure**—Gas storage and control problems are simplified, Beardshall and Fitt noted, if atmospheric pressure during flight is maintained at a figure somewhat below ground level. Since the pressure within the compartment will have been approximately equal to that of ground level, a method must be chosen for allowing the cabin pressure to drop to flight level—say 18,000 feet.

Two methods are possible, they declared. One is to use a simple relief valve that limits vehicle pressure to a maximum allowable figure. This would take care of possible overpressurization caused by malfunction of oxygen supply equipment. The second method would employ an aneroid controlled valve to increase atmospheric pressure if it falls below an established minimum.

Whichever means is chosen, the maximum rate of decompression will reach about 0.75 psi/sec. for an acceleration of 6 g. This is more rapid than advisible for a passenger embarking on an already hazardous journey. Beardshall and Fitt suggested the use of a relief valve with built-in restriction to slow the rate of decompression to about 0.25 psi/sec.

Basically, the system for maintaining a satisfactory atmospheric environment is made up of oxygen supply and facilities for removing excess carbon dioxide and water vapor. Re-

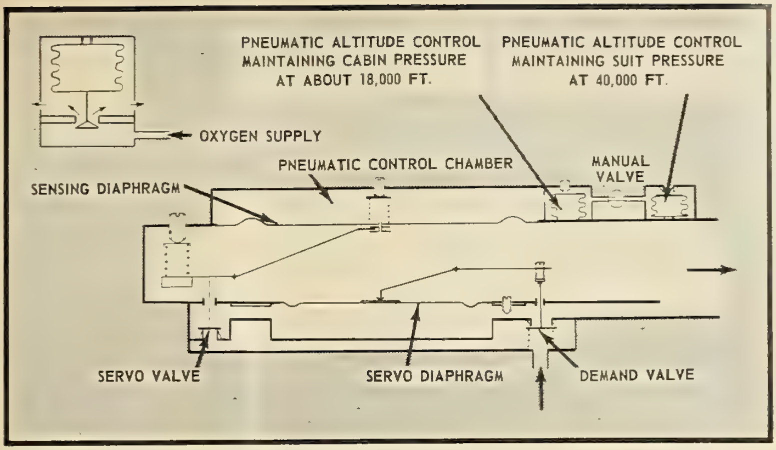

PNEUMATIC ALTITUDE CONTROL MAINTAINING CABIN PRESSURE AT ABOUT 18,000 FT.
PNEUMATIC ALTITUDE CONTROL MAINTAINING SUIT PRESSURE AT 40,000 FT.
OXYGEN SUPPLY
PNEUMATIC CONTROL CHAMBER
MANUAL VALVE
SENSING DIAPHRAGM
SERVO VALVE
SERVO DIAPHRAGM
DEMAND VALVE

FIG. 2—Pressure controller regulates the flow of oxygen both to the cabin and to the suit used in case of atmospheric contamination in the cabin.

moval is accomplished by circulating cabin air through absorbing chemicals. Since CO_2 and H_2O are produced as a result of oxygen consumption, the oxygen must be steadily replaced.

• **Heaviest item**—The oxygen supply and its container are the heaviest item in a cabin conditioning system. A gaseous oxygen supply was rejected because of the obvious problems entailed by the size of its container. Storage in chemical form would raise problems in conversion to breathable form. Storage in liquid form would pose the fewest difficulties. Beardshall and Fitt reported, even though it would require refrigeration below −119°C.

A typical liquid oxygen supply, of the kind used for aircraft, is shown in Fig. 1. The liquid is stored in a Dewar vessel made of materials such as copper or stainless steel. The vacuum jacket eliminates, as far as possible, any heat transfer that might warm the oxygen above its boiling point.

The liquid passes by hydrostatic head to the external circuit to be vaporized. Continuous introduction of heat to the inside of the container warms the liquid and raises the vapor pressure above its surface until an automatic cutoff valve stops circulation.

Two features of such a converter prevent its use in its present form in space travel, Beardshall and Fitt declared. First, those now being produced in the size needed for a one-man expedition suffer evaporative loss at a rate closely paralleling one man's consumption. For example, a 5-liter converter can lose 20%, or about 2½ pounds of oxygen per day.

A man in a sealed environment consumes less than 1 lb. daily. Some 5-liter converters show loss of less than 1 lb. per day. Obviously, there is little margin for controlling rate of flow. For longer flights, there is no reliable evidence that any converter will contain oxygen much longer than 20 days.

A second objection is that it is difficult to predict the condition of the liquid oxygen at zero-gravity conditions. It probably would be a suspension of droplets in mist form, according to Beardshall and Fitt. Under such conditions, a fall of pressure would follow any draw-off from existing converters. They said it would be necessary to revise the circuit completely to provide some means of restoring the pressure.

• **Oxygen flow**—A controller in the system must regulate a flow of about 2 liters/min. of oxygen under normal conditions, even under the severest work conditions. It could be an aneroid set to open a small valve in the oxygen delivery line when cabin pressure falls below the established minimum. Fig. 2 illustrates such a unit.

Impurities are removed from the air on a short flight by a chemical means only. On a 10-day trip, there is nothing to be gained in attempting to generate oxygen from the waste carbon dioxide. The weight of the equipment or plant life would be prohibitive. Nor is there any major objection to carrying sufficient water for the passenger's needs.

For absorbing carbon dioxide, many studies have shown that lithium hydroxide is best. Originally, lithium chloride was used for water absorption. More recently, however, there have been reports that LiOH may absorb some water too. Beardshall and Fitt said research is in progress at Normalair to establish the efficiency of the absorbing chemicals. But regardless of efficiency, they said the system will resemble that in Fig. 3.

• **Circulation**—A fan and motor will be needed to maintain a proper rate of circulation through the absorbents. This will require power, another drain on the vehicle's auxiliary power supply. They noted, however, that in the event of failure, the passenger can provide his own circulation by breathing directly into the chemicals.

The final overall system (Fig. 4), Beardshall and Fitt reported, would require from 55 lbs. for a two-day flight to 235 lbs. for 10 days, and could be available in a relatively short time.

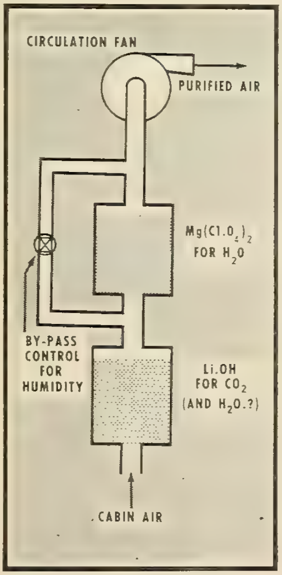

CIRCULATION FAN
PURIFIED AIR
$Mg(C1.0_4)_2$ FOR H_2O
BY-PASS CONTROL FOR HUMIDITY
Li.OH FOR CO_2 (AND H_2O.?)
CABIN AIR

FIG. 3—Chemical absorption system removes CO_2 and H_2O from the air in the cabin.

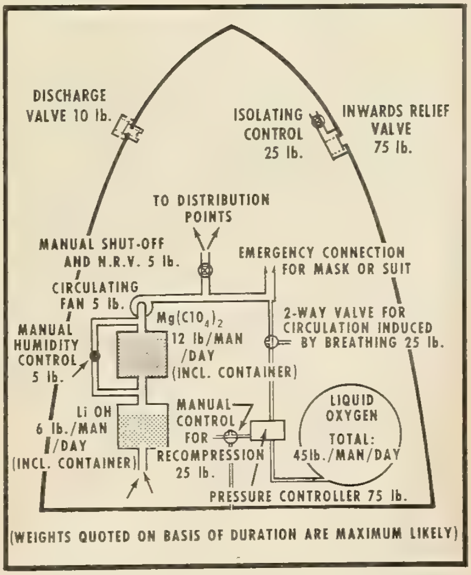

DISCHARGE VALVE 10 lb.
ISOLATING CONTROL 25 lb.
INWARDS RELIEF VALVE 75 lb.
TO DISTRIBUTION POINTS
MANUAL SHUT-OFF AND N.R.V. 5 lb.
EMERGENCY CONNECTION FOR MASK OR SUIT
CIRCULATING FAN 5 lb.
$Mg(C10_4)_2$ 12 lb/MAN /DAY (INCL. CONTAINER)
MANUAL HUMIDITY CONTROL 5 lb.
2-WAY VALVE FOR CIRCULATION INDUCED BY BREATHING 25 lb.
Li OH 6 lb./MAN /DAY (INCL. CONTAINER)
MANUAL CONTROL FOR RECOMPRESSION 25 lb.
LIQUID OXYGEN TOTAL: 45lb./MAN/DAY
PRESSURE CONTROLLER 75 lb.
(WEIGHTS QUOTED ON BASIS OF DURATION ARE MAXIMUM LIKELY)

FIG. 4—Complete control of atmospheric environment is provided by the cabin conditioner. Here is the scheme of the overall system.

live and kicking . . .

ARPA Keeps Its Space Research Role

by James Baar

WASHINGTON—As the fog of press releases drifts away it has become increasingly clear that there was far less than met the eye in the Pentagon's much-noted announcement on the distribution of ARPA's space holdings.

ARPA pinched itself and like Mark Twain found that it was in a position to say that the reports of its demise were much exaggerated.

In fact, there will be no funeral at all. And for a very simple reason: There is no body.

The net effect of the Pentagon announcement—and a letter to the Joint Chiefs of Staff from Defense Secretary Neil McElroy that was the basis for it—is this:

- The Air Force has been made responsible for (as McElroy put it) "development, production and launching of space boosters and the necessary system integration" connected with them for all military purposes—"except for such research and development as may be conducted by ARPA."
- Four ARPA space projects—*Samos, Midas, Notus* and *Transit*—have been assigned to the military services: the first two to the Air Force; *Notus* to the Army and *Transit* to the Navy. However, their actual transfer with supporting funds may not come for one to two years, and before that takes place ARPA will remain responsible for them.
- ARPA will continue as the Defense Department's agency for advanced military research both for both space and more earthbound projects.
- The effect on NASA is nil.

The assignment of the four projects by McElroy was nothing more than part of the overall plan for development of advanced programs under ARPA direction until they reach a stage of R&D where the Defense Department feels they should be turned over to a military service to complete their development and operate them. (M/R, Sept. 28)

ARPA Director Roy Johnson has said projects should be assigned to the military services that will use them about two years before the projects are operational. ARPA has been pressing the Joint Chiefs of Staff for months to begin making such assignments.

However, the Joint Chiefs have been been unable to reach agreement on who was to get what. And the first four assignments are understood to have been made by McElroy in the face of continued disagreement among the Joint Chiefs.

It is noteworthy that the ARPA satellite detection fence that has been developed by the Army and Navy was not assigned although its assignment is far more due than that of the early-warning *Midas* satellite.

As yet, no calendar for the transfer of the four assigned projects has been worked out. However, McElroy's letter makes clear that the transfers involve much more than an automatic process.

He said that "prior to assuming responsibility, the appropriate military department will submit to the Secretary of Defense detailed plans for the system including user relationships with the unified and specified commands and other appropriate agencies."

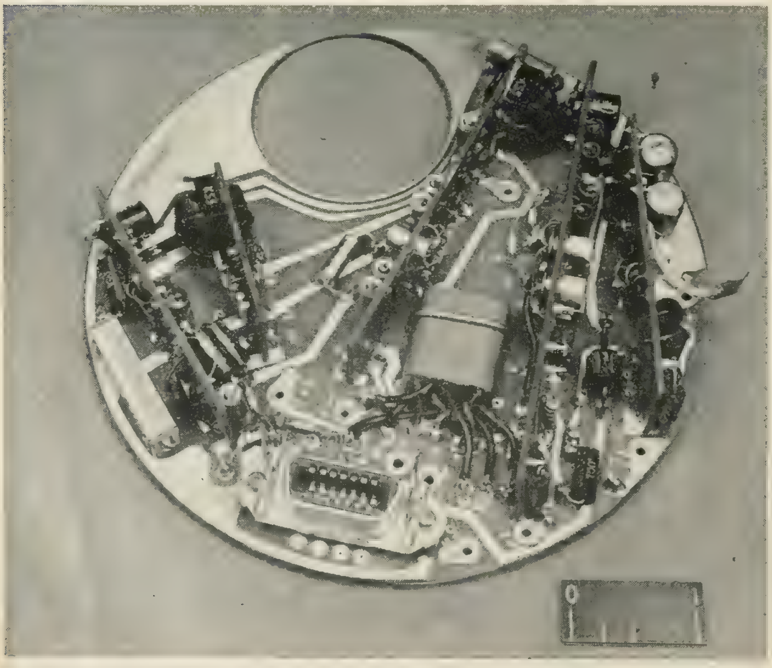
Moreover, he said the transfer must pass through the Joint Chiefs and the office of Pentagon R&E Director Herbert York. He said "the date of transfer . . . from ARPA will be approved by the Secretary of Defense upon the recommendation of the Director of Research and Engineering."

One of the earliest of the projects to be transferred may well be the *Samos* reconnaissance satellite. The *Transit* navigational satellite probably will come next, about a year or so from now.

The transfer date for both *Midas* and the *Notus* communications system of satellites is anybody's guess. One of the complicating features about *Notus* is that it is really four satellites and McElroy's letter spoke only of the "interim communications satellite." That could mean only the first one—*Courier.*

McElroy's letter left wide open the fate of *Saturn,* the clustered 1.5-million-pound-thrust booster being developed by the Army Ballistic Missile Agency for ARPA. But it forced farther into the open the bitter struggle over the Army space program.

Subsequent comments by York made clear that whatever happens to *Saturn,* the Army's days in the space business appear numbered.



THE ARPA-ARMY Project *Courier* delayed repeater communications satellite, in an advanced state of development, contains this electronic equipment.

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Ignition Keeps Pace with Challenges

Present trend is toward hypergolics for restarts and pyrotechnics for single-shots—both may be passed up in future systems. Part I of a two-part survey.

by **Frank G. McGuire**

LOS ANGELES—A highly reliable ignition system is, by its very nature, the heart of engines using chemical combustion products. Despite this basic importance, it has until now received little attention in technical writing.

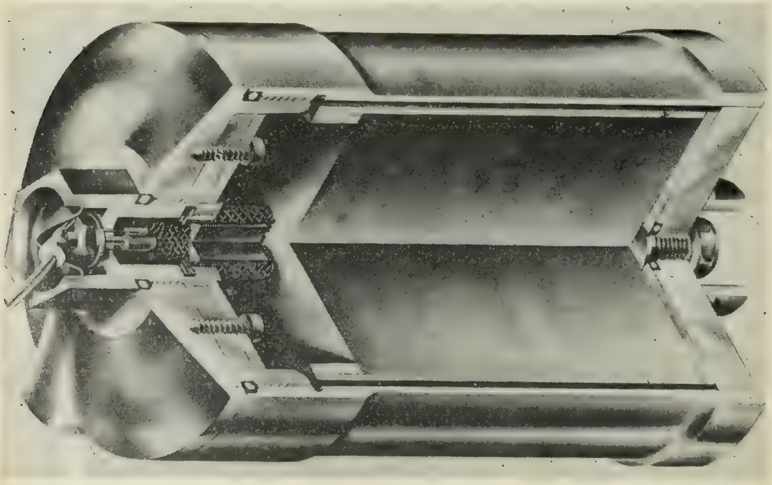
Ignition has come a long way since the days when a 13.5¢ dynamite device was used in rockets—the final cost of a system nowadays may run into literally thousands of dollars. But this is misleading—the basic cost of a unit may be only 5% of this final cost; the rest can be chalked up to quality control, lot acceptance testing and various other costs.

Qualification testing has, at times, cost one hundred times as much as development costs of a unit. And development costs have been known to reach ten thousand times the production cost. Even the 13.5¢ dynamite igniter has doubled in price since the days when it was a standard item.

Many manufacturers are involved in ignition system work. M/R is indebted to **Aerojet-General, Holex, Inc.,** and **McCormick Selph Associates** for the material in this roundup. Other companies and organizations active in this field include: **Beckman & Whitley; Ordnance Associates; Propellex; American Potash & Chemical; Redel, Inc.; B G Corp.; Bendix Aviation, Scintilla Div.; Librascope; Ordnance Research and Development Co.,** and many other companies.

The various types of ignition systems can be generally classified into six categories: pyrotechnic, electrical, torch, hot-spot or heated wall, catalytic, hypergolic. Combinations of these are used frequently, of course, depending on requirements. The prime consideration in many instances is reliability under operating conditions. This is set at reliability levels of 99.99%, and in cases where multi-stage vehicle has as many as 50 pyrotechnic initiation systems, the desirable becomes the necessary.

The choice of a system may be influenced by characteristics of single or repetitive starts, peculiarities of the combustion process, altitude starting conditions, high-pressure chamber conditions, methods available for initiation, timing, and type of installation.



PYROTECHNIC igniter installed by Aerojet-General in a gas generator. Pyrotechnic devices have been greatly improved and are probably the most-used system.

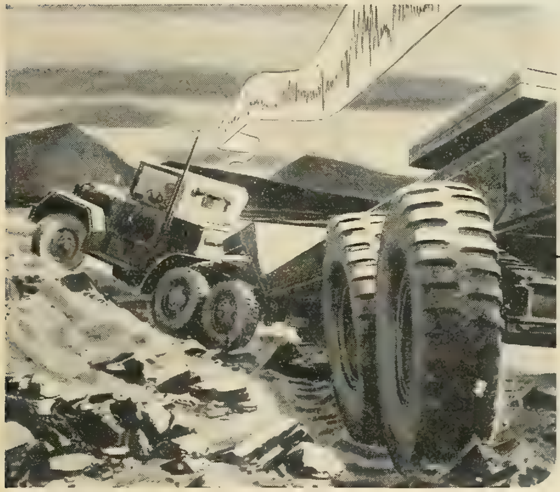
- **Pyrotechnic progress**—Probably the most widely-used type of ignition system currently is the pyrotechnic device. These have steadily increased in reliability, resistance to environmental conditions, shelf life, control of ignition delay-time, uniformity of performance, elimination of ignition shock (brisance), high ignition temperatures, high-altitude starting, direction of combustion products, and safety.

Most rocket engines require raising pressure and temperature in the combustion chamber to predetermined values to insure positive initial ignition and sustained combustion of the propellant. Once this has been accomplished, the characteristics of the combustion chamber nozzle are such that propellant combustion will be maintained after termination of the ignition phase.

To achieve the required conditions, a pyrotechnic ignition device is usually comprised of three elements. In order of initiation, they are the ignition primer, the ignition booster, and the main igniter charge. Variations of this setup may occur in small engines, where only the first two of these would be used, or very large engines, where all three would ignite a miniature rocket engine, which in turn has to provide sufficient temperature and output to ignite a large mass of propellant in the main engine.

Black powder igniters, long a standard item, have been replaced because of their variable performance, excessive functional violence and other poor qualities. To supersede black powder, Aerojet-General developed a binary pyrotechnic composition containing aluminum powder. This mixture, registered as "Alclo", has desired properties of high temperature, fast burning, high caloric evolution, ignition flash point temperatures over 500°F, and absence of ignition shock. The "Alclo"

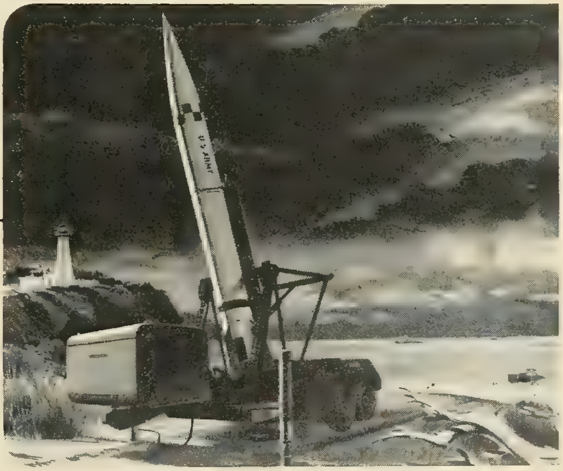
Pioneering Achievements in Missile Support Equipment at JPL



VEHICULAR EQUIPMENT . . . has been designed and developed having greater stamina and of much lighter weight. Specially designed prototype units were tested on rough terrain under the severest operating conditions. From these tests, significant design data resulted.

GROUND HANDLING EQUIPMENT . . . for servicing missiles and readying them for launching has been designed, developed and tested. However, a continuing program is in process at the Jet Propulsion Laboratory to further the state of the art in this important field.

MOBILE MISSILE SYSTEMS . . . were designed, developed and tested for use in transporting and servicing missiles. A tractor-trailer with launching pad in one complete unit was developed. Other equipment for loading and transporting missiles via air, land or sea has been developed.



GROUND SUPPORT EQUIPMENT . . . is developed to operate under conditions of rain, snow, ice, and heat. Mud and desert sand also create difficult environmental problems. Objectives are ease of operation and handling permitting the missile to be readily unloaded from airplanes, or landing craft and quickly positioned for firing.

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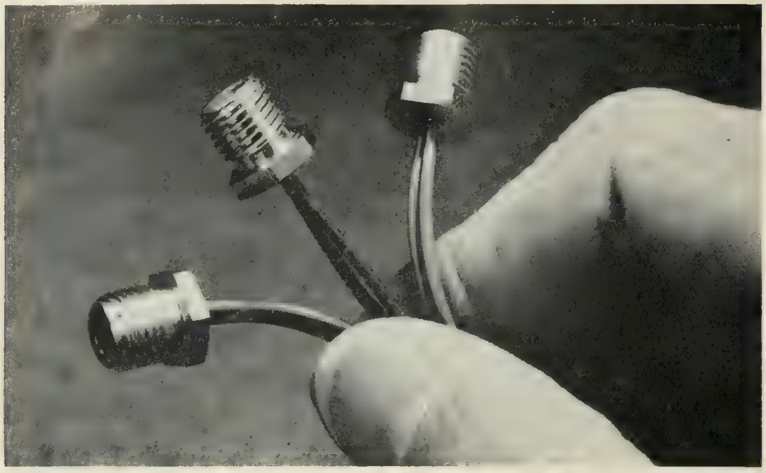
designs have steadily improved . . .



FIRST IN the order of initiation is the ignition primer, tiny but with very high reliability. Here is a trio of Holex, Inc. Model 1029B high-altitude primers.

composition is usually pelletized.

In a system using these components, the ignition primer is ordinarily fired by passing an electric current through a resistance wire to raise the wire temperature above the ignition temperature of the primer composition which surrounds the wire. Flame temperatures in ignition primers run around 3000°K, brisance is low, and a high degree of reproducibility of the flame pattern is required. The low brisance, or shock, output is necessary to minimize mechanical stresses on the igniter booster load.

(A high-shock-producing ignition primer could shatter the pellets of the main igniter charge, changing the burning area of them, and give a different pressure vs. time output, thus producing an unpredictable igniter action. The resulting flame pattern might not produce the necessary complete envelopment of the propellant.)

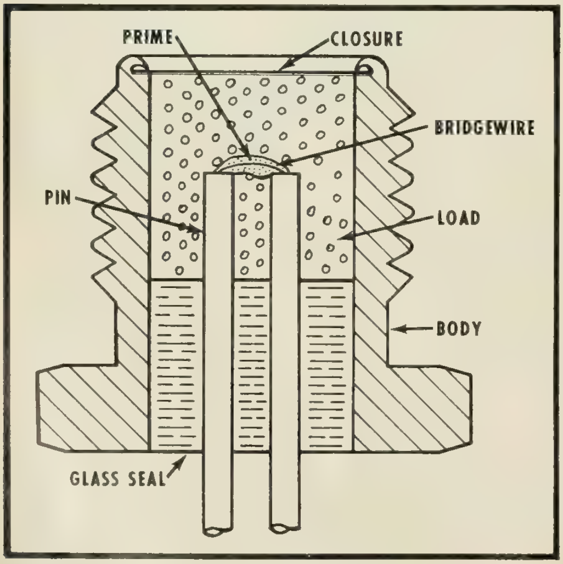
• **Design changes**—In addition to the composition of the charge, igniters have changed structurally. Early models consisted of a gliding metal case, sealed by a phenolic plug through which the electrical leads projected. The initiating bridge-wire was soldered to the ends of the leads and primed with a bead of heat-sensitive material. The main charge, as mentioned previously, frequently consisted of various granulations of black powder.

Improvements in this design include the use of the dual bridge-wire, glass-to-metal-seal type igniter that is highly reliable, easy to install, has three milliseconds or less ignition delay, is not affected by prolonged flow of sub-critical voltages, and is not subject to ignition by atmospheric electrostatic discharge. It generally uses an explosive bridge-wire, instead of a low-voltage prime explosive squib.

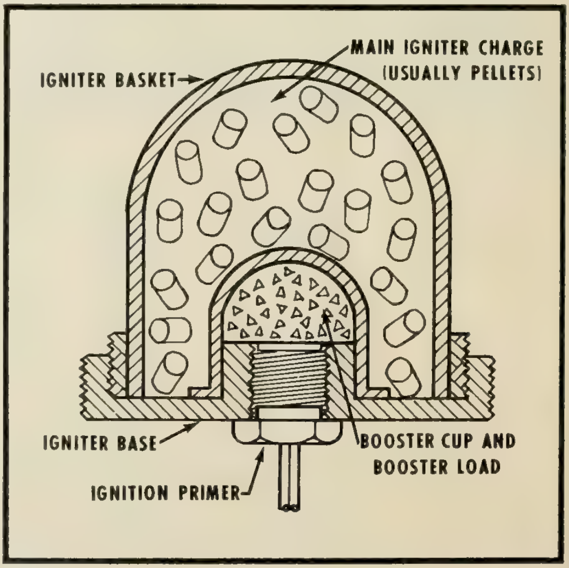
Another improvement is the use of flame directors and perforated metal baskets that produce a large ball of flame. In addition, the ignition interval is now ¼ of what it was in early models.

In addition to the development of improved charges, such as Aerojet's "Alclo" and others, the glass-to-metal seal pioneered by McCormick Selph Associates has done much to bring pyrotechnic systems to their present level. Mc/S/A feels it made the first significant contribution along these lines by using the glass-to-metal seal for getting electrical energy into the case while still providing a pressure seal. Most companies now use the technique.

As a result, the most recent models of ignition primers use the design encompassing a steel body with a hermetic glass-to-metal seal through which the electrical leads enter the primer cavity. Threading is provided to allow easy installation and removal, as well



CROSS-SECTION of Holex Model 1029B high-altitude ignition primer. Extreme quality control is applied.



TYPICAL IGNITER cross-section is shown in another diagram by Holex. Flame temperatures are near 3000°K.

EXTENSIVE DOW PRODUCTION FACILITIES FASHION VARIED NEW MAGNESIUM WARES

Coiled sheet, thin wall castings, many other production items are now available from Dow's big rolling mill, foundry and fabrication facilities.

Manufacturers on the alert for improved materials and production methods would enjoy a quick tour of the four Dow plants that turn out magnesium products. New ways of forming and fabricating magnesium now being practiced in these plants open up new areas of use for the lightweight metal.

TOOLING PLATE, extra flat, is annealed to eliminate residual stresses.

At the huge Madison, Illinois, rolling mill, for example, they're making magnesium sheet that doesn't require stress relief after welding. This is a major step forward in light metal technology and a boon to manufacturers using magnesium assemblies. Madison has also increased the maximum width of sheet to six feet. Five different sheet alloys, including elevated temperature alloys, are now available either flat or in coils.

To keep abreast of the rapidly increasing demand for precision jigs and fixtures, Madison keeps a close watch on the tolerances of Dow magnesium tooling plate. Typical flatness tolerances, for example, are 0.010 inches in any six feet. This means greater accuracy and less machining for users of Dow tooling plate. A mammoth 13,200 ton extrusion press, also located at Madison, is now turning out magnesium extrusions up to 30-inch circumscribed circle in size.

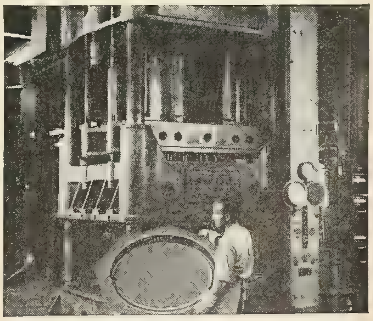
Over in Bay City, Michigan, interesting things are happening, too. At the well-equipped Dow magnesium foundry, largest in the U. S., sand and permanent mold castings of all sizes and shapes are being produced on a volume basis. Complete facilities are maintained for heat treatment, styrene DMI impregnation and chemical treatment. A well-staffed quality control team makes sure that all specifications are met or exceeded, and that the most modern equipment and techniques are fully utilized.

The Bay City foundry casts many complex and difficult designs. Large castings with walls as thin as 0.100 are now being produced. Other useful developments include cast-in tubeless passageways for use as hydraulic lines, special coring techniques for casting enclosed shapes and new magnesium casting alloys.

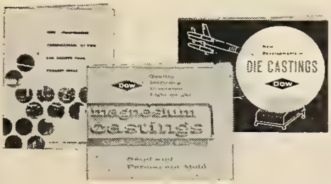
DOW FOUNDRY offers production capacity for sand and permanent mold castings of all sizes.

A new die casting plant is now on stream at Bay City. This facility houses the most advanced magnesium die casting equipment, including cold chamber metering units which automatically feed metal to the machines and contribute to unusually high production rates. To assure close alloy composition control in both die casting plant and foundry, a direct reading spectrometer provides frequent and precise analyses of the molten metal. Similarly, X-ray equipment is also available where radiography is needed in quality control.

The Dow fabrication plant, also in Bay City, offers capacity for volume work on magnesium assemblies. Here, too, developmental work on magnesium is constantly in progress. The plant is set up to handle large or small jobs, and plenty of both. Its activities include deep drawing, bending, spinning, stamping, piercing, machining, arc and spot welding, assembly, chemical treatment and painting. This plant has pioneered many "firsts" in magnesium production, such as hot drawing, spot welding and automatic welding.



LARGE DRAW PRESS at Dow's fabrication plant forms magnesium sheet in one operation.



WRITE TODAY for more information about Dow's magnesium production facilities. Request "Fabrication Brochure", "Foundry Brochure", "Die Casting Brochure" or all three. **THE DOW METAL PRODUCTS COMPANY,** Midland, Michigan, Sales Department 1351CL10-5.

DOW

THE DOW METAL PRODUCTS COMPANY
Midland, Michigan
Division of The Dow Chemical Company

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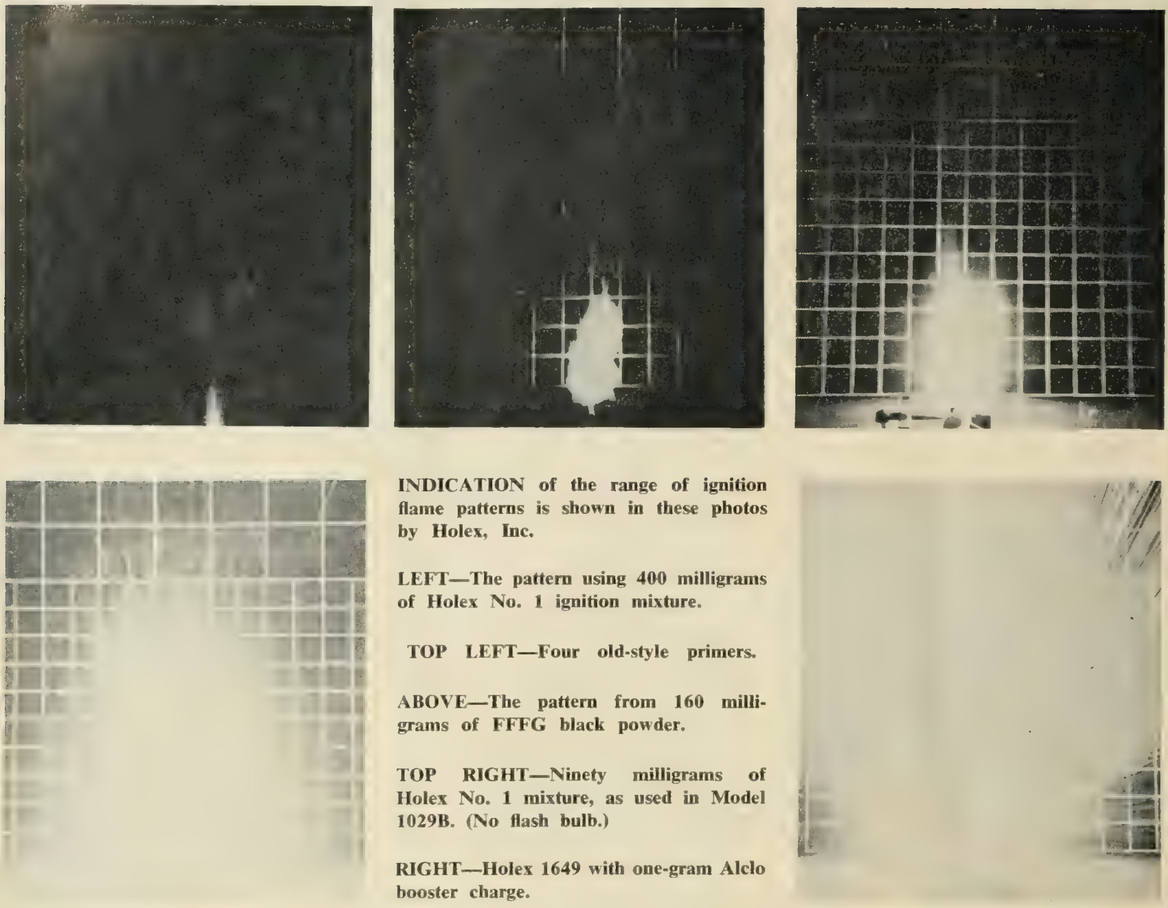

INDICATION of the range of ignition flame patterns is shown in these photos by Holex, Inc.

LEFT—The pattern using 400 milligrams of Holex No. 1 ignition mixture.

TOP LEFT—Four old-style primers.

ABOVE—The pattern from 160 milligrams of FFFG black powder.

TOP RIGHT—Ninety milligrams of Holex No. 1 mixture, as used in Model 1029B. (No flash bulb.)

RIGHT—Holex 1649 with one-gram Alclo booster charge.

as a positive seal of the igniter assembly as a whole. The metallic closure at the other end of the primer body is mechanically and chemically bonded in place.

The bridge-wires in these modern units are generally resistance-welded to the electrical leads of the unit, rather than soldered, and extreme quality-control steps are taken to insure a secure weld that will withstand shock, vibration and high thermal shock.

The environmental stresses which these units must be able to withstand are varied: a 40-foot drop without actuation or impairment of future ability to actuate normally; guaranteed not to fire at 0.5 ampere, but guaranteed to fire at 3.0 amperes; twenty immersions alternating between liquid oxygen and boiling water without impairing operating characteristics; and operational capability over 250,000 feet.

Ignition primers of this general type (specifications vary widely, of course, including the no-fire/all-fire electric current specs) have high reliability. They are basically susceptible to one failure in five thousand units for a single-bridge-wire part, and one failure in a half million units for a dual-bridge-wire unit having separate power supplied to each bridge-wire.

The construction of the opening through which the ignition mixture fires has a great deal to do with the resulting flame pattern. Tests conducted by Holex, Inc., have shown that some charges of 160 milligrams of explosive (in this particular case, it was FFFG black powder), can create a flame pattern more intense and larger than 600 milligrams of the same explosive. The difference consisted of a smaller opening, ⅛-inch, through which the larger charge fired. This allowed greater opportunity for heat transfer to occur and increased the velocity of the gases, both actions resulting in a cooler pattern. Increasing the size of the opening to ¼-inch eliminated this problem.

• **Testing and qualification**—In the early stages of ignition system development, as many as 10,000 ignition primers have been fired to obtain a statistical reliability level. This volume was necessary because individual units did not have the required reliability, and forced resort to a measure of redundancy. The extent of the redundancy was determined through large volume tests that established a reliability figure.

Quality control and reproducibility of the action of modern primers has made it possible to determine a statistical reliability level through testing a smaller number of units. A lot of 1200 ignition primers might require destructive testing of only 200 units. This leaves 1000 for operational use, and generally allows a lower overall production figure.

It has been found that this level of testing is adequate for the newer, more sophisticated primers now being made, and that no significant increase in re-

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liability would result from testing a larger percentage of units. It has been maintained in the industry that this results in higher costs per individual unit, but total costs, when applied to a complete program, are probably equal, or even less, for the same or a higher degree of ultimate reliability.

• **Design considerations**—Until relatively recently, rocket engine manufacturers often purchased an ignition primer from the primer manufacturer, then incorporated this device into an ignition system of their own design. Increasing demands on environmental factors have caused a shift away from this policy to one of subcontracting the entire ignition system to a producer specializing in this field. Given the specification for such a system, the subcontractor then has complete responsibility for design, test, and production of it, and ultimate reliability rests on his shoulders.

Ignition system design can be definitely spelled out by the rocket engine prime contractor, using specified design considerations, as follows:

- Size and form factor of the ignition system package.
- Method of inter-connection into the rocket engine.
- Required output, expressed as a pressure/time curve related to the free volume to be pressurized. This curve will normally have upper and lower limits related to the temperature extremes permissible.
- Minimum allowable flame temperature and gas temperature.
- An expression of limitations of gas products. This may include specifications on maximum particle size permitted, percentage of metallic oxides, amount of solid particles vs. gases, and limitations on the maximum permissible corrosive effect tolerable.
- Environmental characteristics. This will include data on the shock, impact, acceleration, vibration, altitude, minimum and maximum operating temperatures, storage temperatures, and other considerations.

This method of completely subcontracting the ignition system does not relieve the rocket engine prime contractor from responsibility for testing the ignition system package to see that it meets specs, but it does allow him to devote more time and resources to design of the rocket engine. The ignition system contractor, on his part, can vary the internal parameters of the igniter package to produce the most efficient and reliable unit.

Once the specification has been established, variations in the type of primer, size and shape of flame pattern, complete environmental testing, and other qualification requirements may now be carried out by the subcontractor without time-consuming technical liaison with the engine producer.

Pyrotechnic ignition system design thus far has kept pace with requirements of rocket engines, both solid and liquid. This will probably be the case for the foreseeable future, since the technologies for both fields are so similar. The engineering and chemistry problems are common to both fields, and it is logical to assume that progress will be comparable in each area.

More advances are expected in reliability and design efficiency as experience and research increase. Every ignition system challenge to date has been met, and industry spokesmen feel that this will continue to be the case.

—reviews—

AN EXPERIMENTAL STUDY OF THE EFFECTS OF NON-UNIFORM WALL TEMPERATURE ON HEAT TRANSFER IN LAMINAR AND TURBULENT AXISYMMETRIC FLOW ALONG A CYLINDER, R. Eichorn, E. R. G. Eckert, and A. D. Anderson, University of Minnesota for WADC. Order PB 151680 from OTS, U.S. Department of Commerce, Washington 25, D.C. 68p. $1.75.

In a study of the measurements of both hydrodynamic and thermal characteristics of flow over an axial cylinder at subsonic speeds, it was found that the boundary layer along an axial cylinder tended to become asymmetrical, as it approached the transition point.

In turbulent flow, this asymmetry vanished again.

For both laminar and turbulent flow the average boundary layer growth was predicted by the standard flat plate relationships. Simple methods were deduced for determining the effective hydrodynamic length of the boundary layers. Local and total heat transfer measurements were made with both laminar and turbulent flow for various unheated starting lengths followed by increasing wall temperatures linearly.

TRANSIENT HEAT TRANSFER IN LAMINAR FLOW IN THE ENTRANCE REGION OF TUBES WITH HEAT CAPACITY, V. S. Arpaci, MIT for WADC. Order PB 151717 from OTS, U.S. Department of Commerce, Washington 25, D.C. $2.25.

Studied was the transient heat transfer phenomenon in laminar incompressible flow at the entrance region of tubes having small length-to-diameter ratios.

In order to create the effect of heat capacity of the tube-wall, the principle of conservation of energy for the tube-wall was considered. This was in addition to the usual fluid continuity, momentum, and energy equations. Since it was assumed that the velocity profiles at the entrance region of the tube could be approximated by the velocities of the laminar incompressible flow over a flat plate, the solution of the fluid flow problem was taken from previous work.

The remaining two partial differential equations, the fluid and tube-wall energy equations, were solved by using successive approximations. A modified Nusselt number based on the step temperature input is defined.

THERMAL BUCKLING OF CIRCULAR CYLINDRICAL AND CONICAL THIN-WALLED SHELLS. Do Abir and others, Polytechnic Institute of Brooklyn for WADC. Order PB 151-740 from OTS, U.S. Department of Commerce, Washington 25, D.C. 169 p. $3.

Results of a theoretical and experimental investigation of the thermal buckling of circular cylindrical and conical thin-walled shells are given.

A 20 KW induction heating generator was used to simulate the effects of aerodynamic heating. The report is divided into six sections, with the first three covering the thermal buckling of circular-cylindrical shells. The remaining three sections investigated circular conical thin-walled shells.

Two basic types of tests were conducted on the circular cylindrical shells. Unreinforced shells were subjected to a thermal output varying in the peripheral direction with about the same longitudinal direction in the first test. In the second trial, circular cylindrical shells, reinforced by axially symmetric longitudinal stringers, were examined at a uniform thermal output.

NATIONAL BUREAU OF STANDARDS' JOURNAL OF RESEARCH, July-August 1959.

The featured article is a complete survey of radio and ionospheric observations made by National Bureau of Standards during the IGY.

The program ranged from the large synoptic network of ionospheric vertical sounding stations to selected experiments concerned with equatorial forward scatter, sporadic-E, radio noise, night airglow, and observations on satellite signals.

Included in a summary of some of these projects and a preliminary report on the results obtained in the following areas of research: World warning agency, ionospheric vertical sounding stations, VHF equatorial forward scatter, radio noise network, radio satellite observations, airglow observations, world data center for airglow and ionosphere.

CATALOG OF TECHNICAL REPORTS ON TRANSISTORS. Order CTR-310 from OTS, U.S. Department of Commerce, Washington 25, D.C. $.10.

A 1959 revision of the catalog lists 146 technical reports on transistors available to industry through the facilities of OTS.

The reports, some printed and others on photocopy or microfilm, are the results of research by the Army, Navy and Air Force between 1949 and June, 1959.

DEVELOPMENT OF WROUGHT BERYLLIUM ALLOYS OF IMPROVED PROPERTIES: PART I,

J. G. Klein, L. M. Perleman, and W. W. Beaver, the Brush Beryllium Company, for WADC. Order PB 151711 from OTS, U.S. Department of Commerce, Washington 25, D.C. 154p. $3.

Rolled and extruded metal of commercial purity was evaluated with regard to its mechanical properties from room temperature to 1200°F.

The structurally modified beryllium developed was compared with the commercial beryllium's fabrication by extrusion and rolling, crystallographic and metallographic structures, and mechanical properties.

Some of the conclusions reached are that preferred crystallographic orientation will improve tensile properties in the direction of work; recrystallization and grain growth must be avoided in cross rolling from extruded bars; beryllium produced from subsieve-size powder and also high-oxide powder, 2.1 to 2.5% BeO, can be used to obtain wrought metal with tensile properties superior to those of commercial grade metal.

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF

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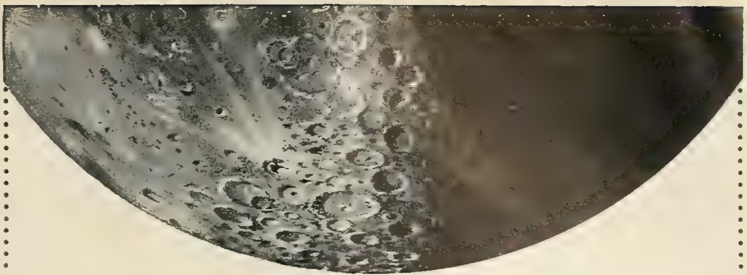
5. The average number of copies of each issue of this publication sold or distributed through the mails or otherwise to paid subscribers during the 12 months preceding the date shown above was: 27,687.

LEONARD EISERER,
(Signature of business manager)

Sworn to and subscribed before me this 14th day of September 1959.

PATRICIA M. SNARE,
Notary Public.
(My commission expires April 30, 1960)



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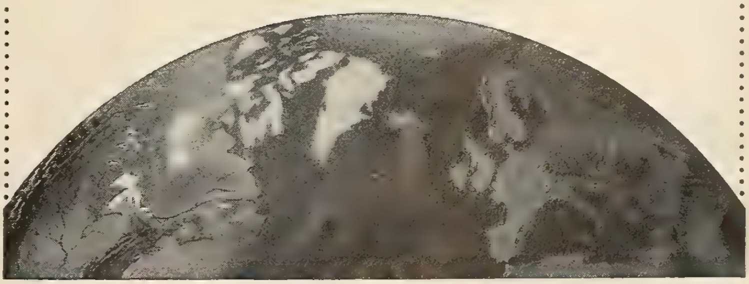

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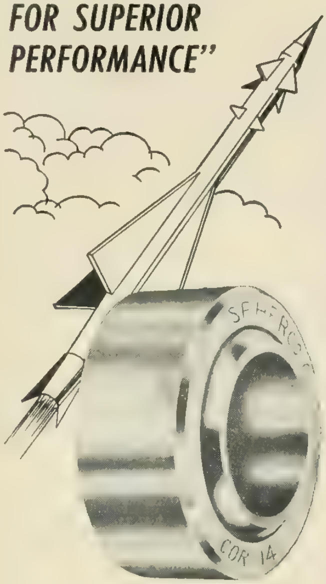

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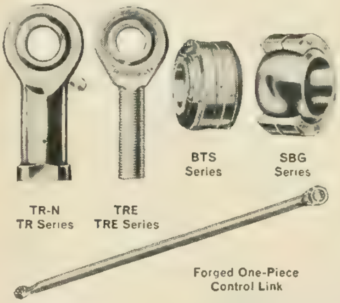

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west coast industry . . .

By FRANK G. McGUIRE

If the steel strike is hurting industry, it isn't the aircraft/missile industries. All indications are that the strike could go into 1960 before a serious pinch developed, although December will bring tighter supply of some special types of metals. Present stockpiles appear to be completely adequate, thanks to anticipation of just such a need. Relatively low production levels in some large steel-consuming airframe firms are also helping avoid a crisis. **Douglas, Lockheed, North American, Aerojet-General,** and other companies have told M/R that, up to this point, there might as well not be a strike. But the pinch will come if the strike goes a few more weeks.

'The West is discriminated against . . .'

says a study made by a UCLA professor of history, Dr. John Caughey. "Spot a factory or distributor in the West, and another in the northeastern U.S.," he says, "and put a customer equidistant between these two suppliers. The freight rate from the West will almost invariably turn out appreciably higher than that from the East." Dr. Caughey concludes that the western United States and the industry here suffers economic discrimination in tariff laws, code of patents, licensing of patents, pricing system, and freight rates.

Magnaflux Corp.'s new test system . . .

for brazed honeycomb panels should substantially reduce inspection costs, if present indications are borne out. North American Aviation is investigating the method of thermographically checking panels for the B-70 and the F-108 before the latter program was cancelled. Although not committing itself, NAA says the system "shows great promise." The **Magnaflux** method, termed Bondcheck, is understood to cost less than $10 per square foot, locating and permanently recording irregularities in brazed honeycomb panels.

Leach Corp.'s Inet Division . . .

in August recorded the highest monthly sales volume in its history, amounting to a potential $2.5 million. Principally responsible were orders for *Titan, Bomarc B* and missile-cruiser support equipment.

Aerojet's subcontract awards . . .

for the past three years have totalled almost $300 million, and small business received $210 million of this figure. The company expects to make over 100,000 separate procurements this year.

Topp Industries' latest merchandising aid . . .

is a hi-fi recording of the automated control system being made by the firm's subsidiary, **Micro-Path, Inc.** The machine uses a stylus-type device to transfer instructions on magnetic tape, and the sound produced forms the basis for a progressive-jazz-like arrangement which has been put on a hi-fi record.

Lockheed's new materials-handling aid . . .

is a vacuum-pad lift bar which enables the company to handle curved panels of 1200 pounds, eight feet by 35 feet, with very little difficulty. Now being used on the Electra production line, the rig easily moves panels from one production station to another without the use of time-consuming rigging operations. The vacuum-pad unit could also take care of complex curved panels on a missile production line.

Rocketdyne's latest *Jupiter* engine . . .

has run up an impressive record of reliability. One engine, #5086, went through 23 consecutive full-thrust, full-duration tests at Redstone Arsenal. The 150,000-pound-thrust engine required only one minor component change in the 24-day-duration series. Over 25,000 items of data were recorded for analysis, and more than a quarter-million gallons of propellant were used by the engine during the series.

- **Cape Canaveral**—An "early" model *Polaris* test rocket was destroyed Sept. 28 when it spun out of control shortly after first-stage separation on a programmed 700-mile flight. It was the third failure in 39 shots.

- **New York**—Maj. Gen. Ben. I. Funk, chief of the AMC's Ballistic Missile Center, says the **Boeing** *Minuteman* "promises to represent a major economic breakthrough" which will enable the nation to maintain ICBM spending at current levels. While not naming any figures, he said the solid-fueled weapon would be "considerably" less expensive than *Atlas* and *Titan* when it is in production.

- **Washington**—In a "clarification" of its "zip" fuel program, the Air Force said it would continue production of boron compounds at the **Olin-Mathieson** pilot plant in Lewiston, N.Y., through the remainder of 1959 and probably into next year. AF indicated that there is still hope the fuels will be useful in rockets and it will employ the 1600 pounds per day of pentaborane and decaborane produced at Lewiston in R&D.

- **Hempstead, L.I.**—The Air Force has awarded **American Bosch Arma Corp.** $53.4 million in contracts for all-inertial guidance systems for operational *Atlas* ICBM's. The company says the "major portion" of support equipment and production test equipment will be subcontracted on competitive bids.

- **New York**—A $42.6 million contract to build, install and test the first 18 underground launching systems for *Titan* sites at Lowry AFB, Denver, has been awarded **American Machine & Foundry.** Contract raises AMF's total *Titan* business to more than $103 million . . . The Air Force says construction of a *Titan* base will start this fall at Ellsworth AFB, S.D., and it will cost $47 million. Contracts will be let in November for construction work.

- **Pasadena**—Now operational: a $3.5-million continuous-flow wind tunnel to test missile stability and control at Mach 9 speeds at **Jet Propulsion Laboratory.** Tunnel is being operated under an Army Ordnance contract.

- **Grand Rapids, Mich.**—A signal from an orbiting U.S. satellite picked up by the Army's Astro-Observation Station at Ft. Monmouth, N.J., and relayed here opened a new $5-million facility of **Lear Inc. Instrument Division,** which manufactures gyros.

- **Washington**—The Air Force cancelled the firing of a **Martin** *Bold Orion* ALBM from a B-47 at NASA's paddle-wheel satellite in the first attempt to test feasibility of knocking down reconnaissance satellites with air-launched ballistic missiles.

- **Reno, Nev.**—The Interior Department announced the development of a simple, cheap method of producing commercial grade tungsten and molybdenum powders for use in alloys. The one-step process reduces the mineral, scheelite, resulting in 99% plus pure tungsten and 98% pure molybdenum through a fused-salt-bath-electrolysis. This is in contrast to the normal costly, commercial processes which do not recover the pure molybdenum.

Rockets Detect X-rays Created by Solar Flares

WASHINGTON—X-rays with energies as high as 80,000 volts have been detected by rockets fired into the upper atmosphere during the recently completed Project *Sunflare II*. The high-level emissions are produced during the most active phases of solar flares, and indicate temperatures as high as one hundred million degrees centigrade.

The solar flare studies were made by Naval Research Laboratory scientists with 12 *Nike-Asp* rockets fired from Point Arguello, Pacific Missile Range. Background for the project was furnished by two previous studies, project *Rockoon* (1956) and *Sunflare I* (1957). Data gained by this early work led to more sophisticated instrumentation capable of the greater sensitivity needed to measure the X-ray flux.

Singer Reports Reds Use Outmoded Magnetometer

WASHINGTON—Soviet space scientists are using a magnetometer 13 years out of date, Dr. S. Fred Singer reported last week.

Singer told an American Rocket Society meeting that the instrument, designed for ground use, takes much more space, weight and power than those used in U.S. research satellites. "They never thought about designing magnetometers for rockets," he declared.

The University of Maryland physicist, a top authority on cosmic and space radiation, said Soviet basic researchers are completely isolated from rocket designers. On his visit to Russia last summer, Singer added, he never met any rocket experts although he had free access to other scientists.

Singer said he has changed his mind and now does not believe the Soviets will soon put a man in orbit. He believes their next spectacular projects will be a near miss of Mars next summer and a "straight up and down" shot of a rocket carrying a man.

Lovell Says *Lunik* Data May Be Inferior to Ours

LOS ANGELES—The U.S.S.R. probably is getting less scientific information from *Lunik I* and *II* than the United States receives from its space probes, according to Dr. A. C. B. Lovell, director of the Jodrell Bank Experimental Station in Great Britain.

Dr. Lovell pointed out that although the payloads *Lunik I* and *II* were massive, they were not as precise or as sophisticated as U.S. payloads.

The British scientist, here on a private visit, also suggested that the U.S.S.R. may have much larger radio telescopes than the 70-foot dishes shown him on his recent trip to the Soviet Union. He noted that *Lunik I* had been tracked for a half-million miles by the Russians, and said none of the equipment he saw was capable of such a feat.

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propulsion engineering . . .

By JAY HOLMES

Nuclear rockets propelled by hydrogen . . .

are a little less exotic than other non-chemical propulsion systems. The technology of nuclear fission reactors is well along. Liquid hydrogen now is available in large quantities. Thus the building of a nuclear rocket is mainly a job of scaling existing reactors up to the power level needed while scaling down their weight. Yet there is opportunity for a major gain in specific impulse. NASA calculations indicate such a powerplant can have I_{sp} of 800 seconds, compared with 400 for the best conventional chemical systems.

Furthermore, big payload fractions are possible . . .

as much as 10%, compared with 3% for chemical propulsion, in ships weighing 75 tons or so. Researchers believe a nuclear booster will be available about 1970 and will be much cheaper than chemical boosters of comparable size. They are thinking in terms of a reactor generating 10,000 to 30,000 megawatts—which would develop 400,000 to 1,200,000 pounds of thrust.

A huge advance in reactor technology . . .

is taken for granted in such thinking. The biggest present reactor—on the ground, of course—generates less than 1000 megawatts and weighs several times 75 tons. Furthermore, chemical systems will be less costly and less complex for lighter payloads. For the monstrous boosters needed for space travel, however, chemical fuel alone could cost as much as $10 million.

A nuclear rocket is conceptually simple . . .

It has one stage. The powerplant is not discarded. The fore portion consists of the astronauts' cabin. A large center section is a liquid hydrogen tank, which also serves as a shadow shield, providing part of the protection against radiation from the reactor, in the rear. The valve system bleeds hydrogen, which boils to cold gas and acts as the reactor coolant. Then the gas passes through the center of the reactor, where it expands rapidly, providing propulsion.

Smaller nuclear rockets will be available sooner . . .

than a nuclear booster—perhaps in five years. A small nuclear rocket, placed in orbit by a chemical booster, could power a space ship to the moon, land, take off, return to earth and re-enter the atmosphere. Lift off the moon requires less thrust because the moon's surface gravity is only 1/6 that of earth. A powerplant designed to do this job might generate 1000 megawatts and give 40,000 pounds of thrust. Even smaller plants, upwards of 10 megawatts, could do some of these jobs.

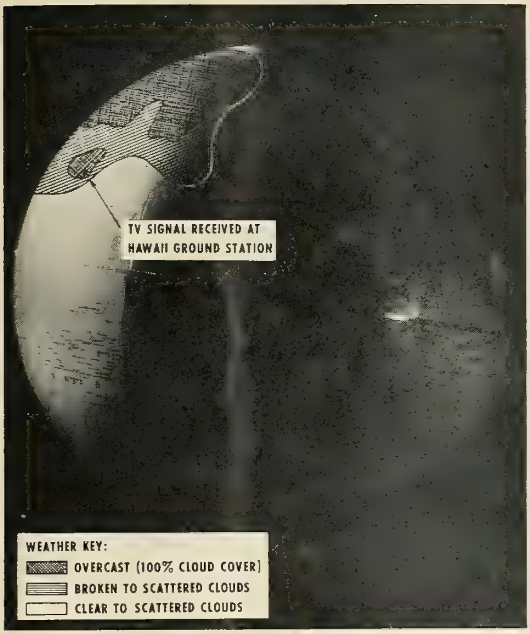
Continuous operation is the big advantage . . .

of a nuclear rocket. The reactor can operate almost indefinitely. The only limitation is the amount of hydrogen propellant; even this isn't much of a limitation—liquid hydrogen is extremely light (0.6 lb./gal.). There's no reason why a nuclear space ship can't maneuver in the space beyond the outer Van Allen radiation belt as long as hydrogen remains in its propellant tank.

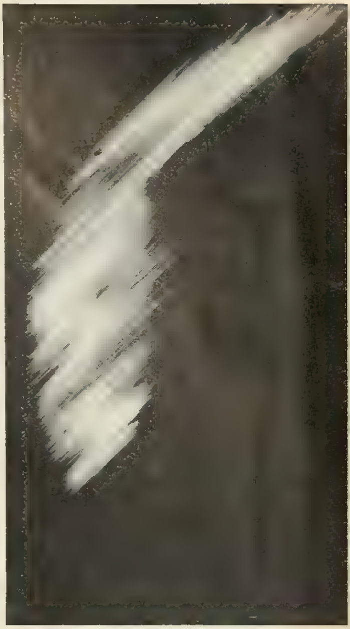
Materials are the biggest barrier . . .

to nuclear rocket development, just as to improvement of conventional powerplants. There are the usual high-temperature problems in designing rocket nozzles, plus one distinctive headache—the nozzle must be made of material that isn't attacked by hot hydrogen. This rules out graphite. Tungsten will withstand hydrogen but it is notoriously weak. The chances are that a powerful, reliable, lightweight nuclear engine will be available for space propulsion by the time the material quandary is solved.

Earth from 24,000 Miles Up


TV SIGNAL RECEIVED AT HAWAII GROUND STATION
WEATHER KEY:
▩ OVERCAST (100% CLOUD COVER)
▤ BROKEN TO SCATTERED CLOUDS
☐ CLEAR TO SCATTERED CLOUDS

SATELLITE'S VIEW OF EARTH—The picture at the right was taken by a two-pound camera device in *Explorer VI* from 20,000 statute miles. The satellite was 24,000 statute miles from the Pacific area pictured. Though not intended for this purpose, the picture distinguishes between cloud structure and ocean reflection to a degree that the picture corresponds to the meteorological pattern of that day. (See picture at left.) NASA scientists feel the test shows that such a system would be feasible to detect cloud formations over a large area from a circular-orbit satellite.



Silica Forming Process Offers New Sizes, Shapes

Corning, N.Y.—The unique thermal and electrical properties of silica glass may be more fully exploited through a new forming process developed by **Corning Glass.**

Called "Multiform" fused silica, the method produces sizes and shapes never before possible and equal to any achieved by conventional ceramic forming.

With properties differing only slightly from those of the parent glass, the product is undergoing evaluation for use as a flush-mounted missile radome.

Multiform-fused silica tends to sublime before melting and plasma jet tests show uniform ablation. The material can suffer long exposure at 1700°F, softens at 2880°F and has excellent resistance to thermal shock.

Center Being Built for Worldwide Monitoring

Mountain View, Calif.—An unusual master control center for worldwide monitoring of satellite flights is being designed and built here by the **Space Communications Division** of **Radiation, Inc.** for **Lockheed Missile and Space Division.**

The development control center (DCC) will continuously receive and evaluate data from an orbiting satellite, receive information direct from all tracking equipment around the world, command this equipment, receive corrections and program data to the satellite, plot world-wide weather, satellite locations and altitude, and keep track of the status of all tracking equipment. In addition, the center will also relay messages via closed-circuit TV to the Vandenberg AFB blockhouse.

The center will go into operation 24-48 hours before launch with a full-dress rehearsal and flight simulation to check equipment operation. After launch, data will be fed into the center by TWX and telephone. Tracking stations will be directed and programmed on the basis of calculations derived from this data.

Charts at the center plot the weather at all stations, the location of the satellite, and the status of all tracking equipment. The center receives instant notice if any equipment breaks down.

A $1.5-million communications system will tie the DCC to the blockhouse, tracking stations, BMD, air rescue service, and other participating facilities.

'Pinch Plasma' Advocated For Future Satellite Use

Washington—Plasma accelerators will be useful for trajectory correction, attitude control and satellite boosters before they are ready to be applied in long-range propulsion.

Bernard Gorowitz, Kenneth Moses and Per Gloerson of **General Electric's Missile and Space Vehicle Department** told the Fourth Symposium of Ballistic Missile and Space Technology at UCLA recently that plasma accelerators could be used sooner in the area of corrective maneuverability.

At Northwestern University, the Third Biennial Gas Dynamics Symposium of the American Rocket Society heard Alfred E. Kunen, manager of the plasma propulsion project at **Republic Aviation,** propose that "pinch plasma" engines be used to power satellites after they have attained orbit.

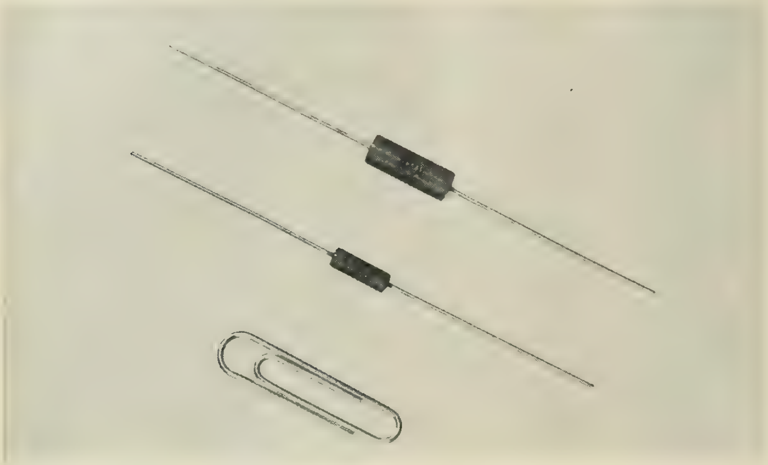
Kunen said that such control would "sharply hasten the day of man-carrying and reconnaissance satellites."

A satellite could then stay in orbit longer, change orbit if need be, and prevent tumbling over itself.

"Pinch plasma" engines would be ideal for this because of their extremely low fuel consumption and low fuel weight.

In operation, the hot gas fuel is changed into a plasma state by electrical discharge in the engine's compression chamber. The current then passes around the electrically conductive plasma, setting up a cylindrical magnetic field. This magnetic cylinder pinches the plasma into a tiny area so designed that it shoots out the rear at very high velocities.

The Republic scientist said that the plasma engine would power a space ship designed for interplanetary flight.



Resistor Sizes Cut by One-half

A totally new method of deposited carbon resistor manufacturing by the **International Resistance Company** has resulted in reduction in size and weight of resistors by more than 50%, the company says.

The advance was signalled by development of a radical new deposited carbon alloy, but this in turn required a redesign of almost every element in the resistor. An insulating spiral path, which determines the resistance value, is now diamond-cut in the much harder alloy film, rather than sand-blasted as formerly. The result is a much more precise incision, with consequent improvement in stability and reliability.

The highly conductive terminating point, which bonds the end-cap connections to the film, is still another new development, according to the maker. Over the resistance element are two new types of moisture-resistant undercoat, also especially developed for this product.

Completing the double-barrier insulation is a new-type molded, break-resistant casing, which, though heavy-duty, is well within MIL size. This molded insulation results in improved load-life characteristics, better dielectric characteristics, and greater opposition to the effects of moisture. It provides all the advantages of ceramic solder-sealed types, without the hazards of seal leakage, breakage and low dielectric strength.

These radically improved resistors are available in ¼ watt, ½ watt and 1 watt sizes, in resistances from 10 ohms to 25 megohms. Standard tolerance is 1%, although 0.5 and 2% types are also available.

Circle No. 250 on Subscriber Service Card.

Retractable Cutter Bar Turner Now Available

New in the field of single spindle bar automatic tooling, a retractable-cutter bar turner is announced by the **Warner & Swasey Co.**

Advantages of the new bar turner, which is designed for the company's 2AB single spindle bar automatic, include highly efficient metal removal with exceptionally close tolerances and smooth, burnished work finishes. Automatic cutter retraction and resetting, according to Warner & Swasey, eliminate tool withdrawal marks and prolong cutter life.

Capable of handling bars from ½" to 2¾" diameter, the new turner clamps directly in the dovetail of the pentagon turret. One coolant line, emanating from the pentagon coolant distributor, is the only separate connection necessary in mounting the bar turner on the machine.

Under cut, the turner's tool holder slide, which is spring-loaded, bears against a spring-loaded stepped cam. Upon completion of the cut, forward motion of this cam is arrested when a screw—connected to the cam—strikes a special stop positioned on the front cross slide housing of the machine. The pentagon turret then continues to feed forward about 1/8" to the end of its stroke, sliding the turner's tool slide off the cam and retracting the cutter.

The cam and cutter are automatically reset in an off-index position by an overhead mounted resetting cam. This resetting cam bears on a roller located on the bottom of the cutter slide.

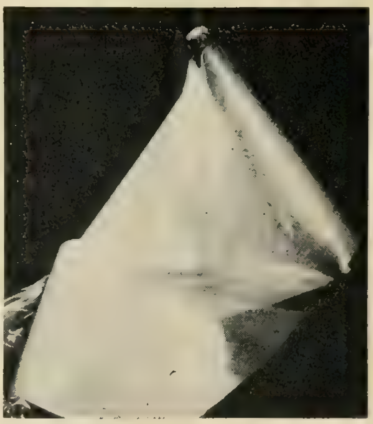
Circle No. 251 on Subscriber Service Card.

Bonding Material Reduces Honeycomb Sandwich Costs

The cost of non-structural honeycomb sandwiches has been reduced by introduction of an inexpensive, easy-to-handle bonding material consisting of cotton cloth and a partially-cured phenolic resin.

Designated as Narmtape 105 by the maker, **Narmco Resins & Coatings Co.,** the new product comes in continuous rolls that may be cut to size with scissors or textile cutters. The tailored sections are then laid in place, and the assembled sandwich heated under slight pressure in order to achieve the desired bond.

Narmtape sharply reduces the total cost of sandwich assemblies. Estimates are that the adhesive can be cut and put in place at a total bonding expense of less than fifteen cents per square foot. This is less than half the cost of most adhesive systems now being used in the construction of honeycomb panels.



Honeycomb bonding presents a special problem, since the adhesive must fasten the thin honeycomb cell walls at right angles to the outer skin—and seldom is the honeycomb cut sufficiently flat for all the cell edges to meet the skin perfectly across the width of the sandwich. Enough adhesive must be provided, therefore, to bridge any gaps that might be present, and to "wet" the sides of the cell walls

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From filament-wound radomes by the unique Strickland "B" Process to honeycomb-core, foam-in-place or anti-icing type radomes, Brunswick supplies the reliability of proven leadership. Write to Brunswick-Balke-Collender Co., Defense Products Division, 1700 Messler St., Muskegon, Michigan.

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to form strengthening fillets.

The flame-proofed cotton cloth in Narmtape 105 acts as a carrier for the modified phenolic adhesive. Impregnated under rigorous quality control procedures at the factory, the cloth assures an evenly-distributed adhesive layer across the entire sandwich area. Following impregnation of the cloth, the adhesive resin is partially cured (to "B" stage). Result: a dry, easily-handled product that can be stored for months at room temperature.

When the assembled sandwich is raised to full curing temperature (approximately 300°F), the resin in the cloth softens and flows to fill the gaps between honeycomb core and skins—then, in less than thirty minutes, hardens into a solid, thermosetting plastic film.

To provide an exceptionally tough, resilient bond, the phenolic resin in Narmtape 105 is modified with a vinyl butyral elastomer. This provides good adhesion with a variety of honeycomb core materials, including aluminum, paper, and fiber glass. Paper and fiber glass cores are usually sealed with a resin coating before bonding. Aluminum sandwich skins are degreased and etched, to obtain maximum adhesion.

Narmtape 105 has a weight of 0.05 pounds per square foot, and an uncured thickness of 0.007 inches. It is available in 36- to 52-inch widths, in continuous rolls with a polyethylene film separator. In the cured state, the adhesive system has a tensile-shear strength in excess of 2500 psi on aluminum, making a strong and stable bonding agent for such applications as fabrication of architectural panels, truck bodies, and insulating walls.

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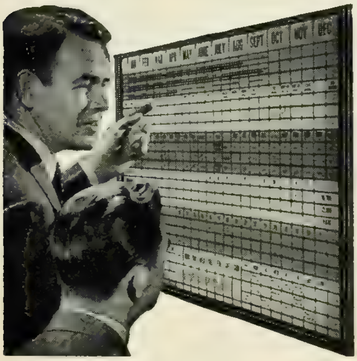

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Computer Searches Tape File, Types Information

The Univac Tape Searchwriter, an integrated system which provides an economical method of searching a magnetic tape file for a desired item and then automatically types the information, has just been announced by Remington Rand Division of **Sperry Rand Corporation.**

Users of Univac II computing systems will find it particularly valuable as peripheral equipment. It permits finding tape-recorded records and printing the desired information without consuming computer or programmer time. It may also be used as an error-checking interrogator because it incorporates all the error-checking features found in Univac systems.

The device is transistorized to reduce size and increase reliability. It is conveniently arranged so that typewriter, operating controls, and tape transport are within easy reach of an operator. Except for the tape handler the system is also self-contained. Power supplies, read-write amplifiers, control circuits including bad spot logic, error-checking circuits, and tape control are integral.

A Synchro-Tape typewriter is included, which permits identification of the desired item manually on the typewriter keyboard or automatically from previously prepared paper tape. When the search is completed and the sought-for item located, the typewriter types the information or punches it on paper tape, or both, as desired.

Any standard Univac characters can be entered from the keyboard or paper tape as the key or identifying data. As the key is entered, it is also printed on the typewriter. When the item is located, it is printed in standard Univac code except that only 44 of the 63 characters are printed as standard characters. The other 19 are printed as a single special symbol. This has been done to prevent the necessity of writing carriage shift characters for the typewriter on magnetic tape.

To simplify switching within the Synchro-Tape typewriter, the punch unit always runs as the key is entered either from the keyboard or from paper tape. When the item is printed or punched, the paper tape may also be operated. The paper tape may be removed in this feed if tape punching is not desired.

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Atlas ICBM Switch's Weight Sharply Reduced

A new motor-driven switch developed by the **Kinetics Corp.**, has saved 43 pounds weight in the *Atlas* missile.

The new switch used in the Series D missile weighs only 7 pounds, compared with a weight of 50 pounds for the switch that was used in the Series A missile.

The new Kinetics motor-driven switch is more rugged and reliable than previous designs and is impervious to shock and vibration. A typical Kinetics switch exhibits no contact chatter over the whole vibration spectrum, from 5 to 2000 cycles, 40g's. The voltage drop across typical switch contacts is less than 10 millivolts at 22 amp.

The high density design results in many more circuits per cubic inch, saving space. There are no permanent magnets or springs, no latching devices. This is truly a motor-driven switch using no elements of relays. The switch can be transferred at 40 g's, 2000 cycles. Once it's transferred, no power is required to hold it in position, saving batteries.

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Magnetic Limit Switch Has No Moving Parts

A new magnetic limit switch which has no moving parts and acts on promixity of its two sensing elements, rather than actual physical contact, has been introduced by Consolidated Controls Corporation, a subsidiary of **Consolidated Diesel Electric Corporation.**

Known as the Amplet magnetic limit switch, the device is seen by its manufacturer as ideally suited to those automation applications where precise control of the relative motion between two parts of a machine is required. Typical applications include limiting cuts or traverse on such machine tools as shapers, planers and drill presses; stopping conveyors at pre-determined positions; continuous sequencing and counting, and automatic weighing and filling.

The device consists of three parts—a probe, which is normally mounted on a stationary part of the machine being controlled; a magnetic trigger, which is mounted on a moving part of the machine or on the part being machined, and a power amplifier, which increases the power output of the probe to useful levels.

In operation, the probe, which is connected by wire to the power amplifier, gives an "off" signal until the permanent magnet trigger, which has no wired connections, approaches within a pre-determined distance. At that distance the probe, without mechanical movement of any kind, gives the electrical equivalent of a "snap" action to an "on" signal condition.

The "snap" action, response time of the unit, requires less than 1 millisecond. By adjusting a sensitivity control on the power amplifier, the distance between probe and trigger at which action takes place is variable from .020 to .200 inch. When motion is reversed, the "on" signal remains until the trigger has moved a distance varying from .002 to .02 inches, depending on adjustment, away from the probe, at which point the "off" signal is restored. The point at which action takes place is repeatable within .001 inch if relative travel paths between probe and trigger are at a constant distance.

Power amplifier units are available either normally "off" or normally "on." In the latter case, of course, action is the reverse of that described above.

Power input to the unit at full load is seven watts of 115-volt, 60-cycle AC. The output signal is 50 microamperes in the "off" condition and five watts of 24-volt DC in the "on" condition.

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contracts

MISCELLANEOUS

Tapco Group of Thompson Ramo Wooldridge, Inc., for the development of a miniature accessory power supply. (Subcontract from **Sandia Corporation**). Amount not disclosed.

Tinsley Laboratories, Inc., Berkeley, Calif., for a Schlieren air flow visualization system for a new supersonic wind tunnel near Saugus, Calif. (Subcontract from **Lockheed Aircraft Corp.**) Amount not disclosed.

$2,000,000—**The General Bronze Electronics Division**, Garden City, N.Y., for antenna systems for the ballistics early warning system program. (Subcontract from **General Electric Co.**)

$1,600,000—**Talco Engineering Co.**, subsidiary of **The Gabriel Co.**, for the manufacture of rocket motors, rotational and vertical thrusters and other components.

$500,000—**FXR, Inc.**, Woodside, N.Y., for the design and manufacture of a powerful radar transmitter. (Subcontract from **Cornell Aeronautical Laboratory, Inc.**)

$77,000—**Pacific Automation Products**, for work on the first Azusa Mark II missile tracking system. (Subcontract from **Convair Astronautics**).

$56,000—**Aerojet-General Corp.**, for a feasibility study of the use of small rocket devices for individual combat soldiers.

NAVY

Sylvania Electric Products, Inc., Woburn, Mass., for special switching transistors to be used in the *Polaris* weapons system. (Amount not disclosed).

$445,000—**Consolidated Systems Corp.**, Subsidiary of **Consolidated Electrodynamics Corp.**, Monrovia, Calif., for construction of a data processing system at the Naval Ordnance Aerophysics Laboratory, Daingerfield, Tex.

$70,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for spare parts used in depot maintenance and overhaul of vertical gyro indicators.

$30,000—**Armour Research Foundation of Illinois Institute of Technology**, for conducting investigation to develop ductile beryllium composites and determine the mechanical properties of materials produced.

$28,500—**New York University**, for conducting an investigation and perform tests to develop high temperature resistant resins bases on complex information with organotitanates.

AIR FORCE

$42,600,000—**American Machine & Foundry Co.**, New York, to build, install and test the first 18 operational underground launching systems for the *Titan* ICBM at Lowry AFB.

$15,500,000—**Federal Electric Corp.**, Paramus, N.J., for non-personal services to operate and supply support for the White Alice communications system in Alaska.

$12,105,000—**Kollsman Instruments Corp.**, Div. of **Standard Coil Products Co., Inc.**, for automatic astro compass support equipment and related spare parts and technical data.

$3,000,000—**The Mitre Corp.**, Lexington, Mass., for research, development and advisory assistance for the air defense systems integration division.

$2,166,420—**General Electric Co.**, for long-range search radar antennas for AN/FPS-7 radar system.

$1,000,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for spare parts kits and other spare parts items used in depot maintenance and overhaul of gyroscopic indicators.

$1,000,000—**Westinghouse Electric Corp.**, for electrical equipment to power and guide *Atlas* missile. (Subcontract from **Goodyear Aircraft Corp.**)

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Infrared at ITT includes complete detection systems as well as basic components

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MEDICAL ELECTRONICS
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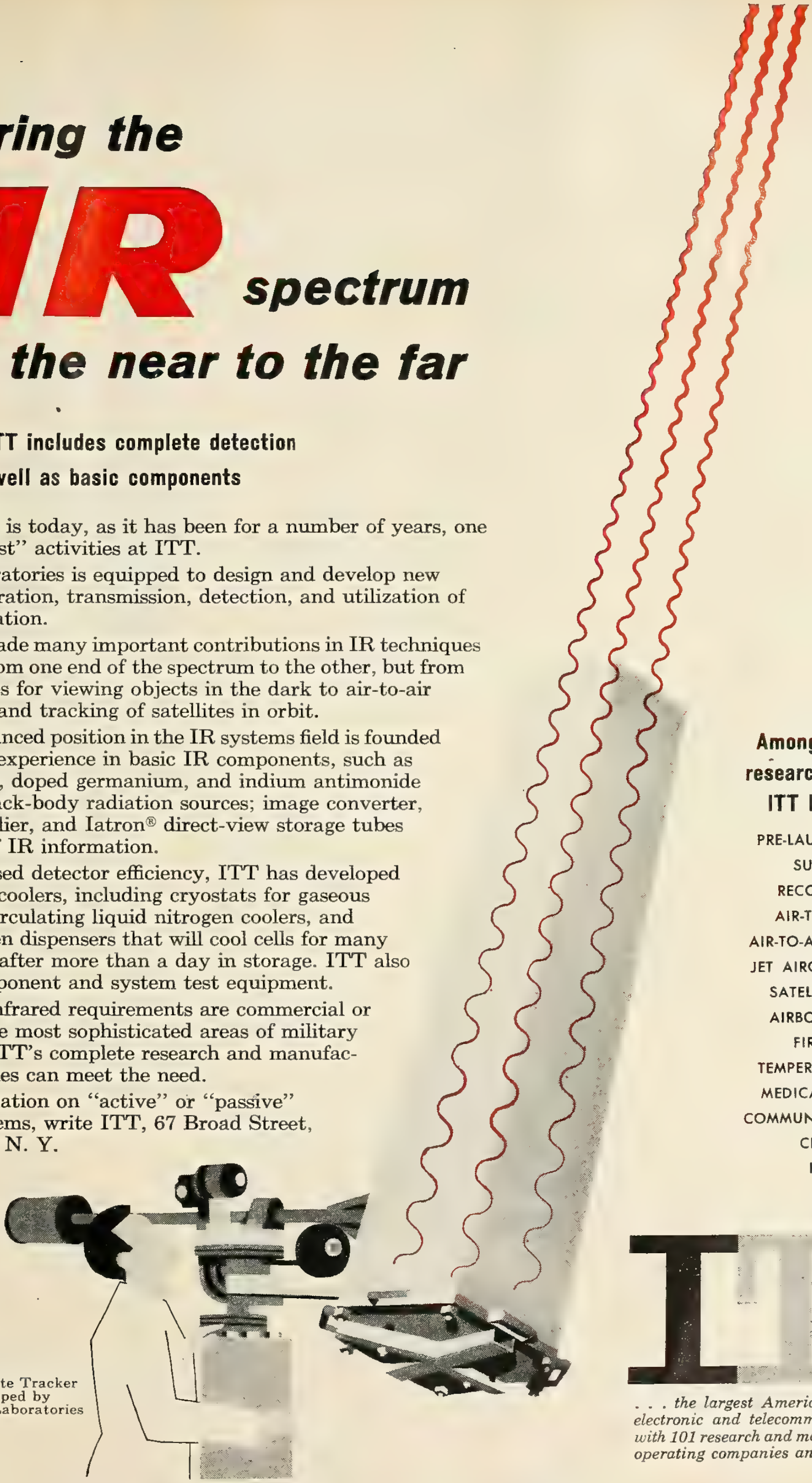

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. . . contracts

$1,000,000—**Raytheon Mfg. Co.**, Andover, Mass., for studying communications techniques for the *Minuteman* ICBM. (Subcontract from **Boeing Airplane Co.**)

$691,753—**Consolidated Electrodynamics Corp.**, Monrovia, Calif., for digital pressure measuring system.

$600,000—**Hoffman Laboratories Div., Hoffman Electronics Corp.**, for the development of a large area solar-electric power system for use in space satellites.

$500,000—**International Business Machines Corp.**, N.Y., for additional facilities and modifications for research and development of an advanced guided missile program.

$500,000—**Radio Corp. of America, Defense Electronic Products Division**, Moorestown, N.J., for one mobile instrumentation radar.

$239,999—**Beckman Instruments, Inc.**, Anaheim, Calif., for multichannel system for analog to digital conversion.

$129,112—**Yardney Electric Corp.**, N.Y., for the production of automatically activated silver-zinc batteries used as primary power sources for the *Minuteman* ICBM. (Subcontract from **Autonetics Div. of North American Aviation, Inc.**)

$54,100—**Ampex Corp.**, Redwood City, Calif., for magnetic tape recorders and magnetic tape.

$50,873—**Documat, Inc.**, Belmont, Mass., for modification of microfilm viewers.

$40,000—**Pennon Electronics, Inc.**, Bell Gardens, Calif., for manufacture of custom magnetic regulated power supplies to be used in ground checkout operations for the *Minuteman*. (Subcontract from **Autonetics Div. of North American Aviation, Inc.**)

ARMY

$30,162,502—**Raytheon Mfg. Co.**, Andover, Mass., for supplemental engineering services and ground support equipment for the *Hawk* missile.

$10,995,680—**Western Electric Co.**, N.Y., for continued work on *Nike-Hercules* missiles.

$750,000—**Collins Radio Co.**, Cedar Rapids, Iowa, for service and materials for one primary tracking station and two secondary satellite tracking stations.

$555,000—**Chrysler Corp.**, Detroit, for support equipment for the *Jupiter* missile.

$359,247—**Raytheon Mfg. Co.**, Andover, Mass., for repair parts for the *Hawk* missile system.

$277,460—**Sperry Rand Corp.**, Sperry Utah Engineering Laboratory, Salt Lake City, Utah, for *Sergeant* missiles. (Two contracts).

$99,832—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for study of mechanisms.

$88,770—**Western Electric Co.**, N.Y., for *Nike* spare parts and components. (Two contracts).

$74,985—**S. R. Brunn Construction Co.**, Kansas City, Kan., for construction of warhead building for *Nike-Hercules* facilities, Kansas City Defense area.

$74,417—**Radioplane Div., Northrop Corp.**, Van Nuys, Calif., for instruction and maintenance of target missiles.

$43,519—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for research and development work on advanced solar energy conversion devices.

$40,000—**California Institute of Technology**, for hypersonic research.

$37,964—**Radioplane Div., Northrop Corp.**, for low-speed drone system.

$37,646—**University of Colorado**, for continued research to study the nutritional adequacy and probable toxicity of foods sterilized by ionizing radiations.

$33,000—**North American Aviation, Inc.**, Canoga Park, Calif., for design and development.

$26,514—**University of Louisville School of Medicine**, for continued research on mechanism of conservation of body fluids.

$21,797—**Douglas Aircraft Co.**, Santa Monica, Calif., for *Nike* spare parts and components.

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- The total value of aircraft and parts produced in the U. S. in 1958 ($11,470-million).
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For the AF—Its Biggest Job

Whether or not you agree with the decision—and there are some who do not—the action of the Defense Department in making the Air Force responsible for all space transportation was a long overdue step toward putting the entire U.S. military space program into an established technological context.

For the first time, it establishes space not as a place but as a field of endeavor. It allows military operations in that field to be viewed in relationship to similar traditional operations. It permits space requirements in such areas as communications, reconnaissance and navigation to be judged not as they relate to space alone but as they relate to the requirements of the military as a whole.

Perhaps this matter of requirements is actually the greatest gain to come from the Department of Defense decision, greater even than the step the decision takes toward solving the entire roles and missions problem.

Military proceedings have long been based on requirements in accordance with missions. A service is assigned a mission. It then develops requirements in accordance with that mission. The requirements, translated into hardware, are tanks, submarines, airplanes—or satellites.

The Advanced Research Projects Agency was established as a palliative after *Sputnik I*, and although ARPA has done excellent work in some cases, it could not escape being an ivory tower when it came to relating requirements to missions. With the present complexity of modern weapons, it has become impractical to adopt anything but a weapon systems approach to production. And under the weapon system concept the parceling out of any major project piecemeal among the services, as ARPA attempted, can hardly fail to produce inefficiency and delays.

General Bernard Schriever, whose adoption of the principle of concurrency in the production of ballistic missiles resulted in chopping almost two years off the estimated production time, told the Senate Space Committee last Spring:

"Weapon System development based on technical feasibility requires that the military do a number of things:

"1. Conduct a vigorous research, applied research, component and subsystem development program.

"2. Conduct constant evaluation and analysis of the above programs, aided by science and industry, to insure timely initiation of space weapon system development programs.

"3. Centrally manage and control space weapon system programs to insure effective systems engineering, integration and testing, which is essential to the intricate technical interface between and among the several subsystems comprising the total weapon system."

General Schriever added:

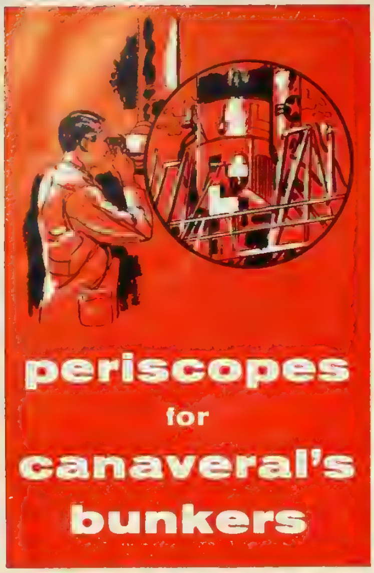
"The ability to apply this philosophy of weapon system initiative to space vehicles will be complicated if there is an excessive division of subsystem development projects among agencies or if there is not a timely decision as to the operator." Later in his testimony Gen. Schriever indicated that placing development of military space projects under ARPA left things complicated indeed.

The decision of the Department of Defense to give the Air Force the role of space transportation does not deny the utilization of the space field to other services. Any service with a recognized requirement can and will develop the necessary equipment. As the using service, it will carry out the research, the evaluation and the management while concurrently producing the support equipment and training the using personnel. In the Navy, as currently programed, this will be a navigational satellite. In the case of the Army—a communications satellite. The Air Force—and the Air Force alone, militarily—has the role of integrating all systems and of putting the satellites in orbit.

The decision to clarify the space roles of the services has been a long time coming. Giving the job of space transportation to the Air Force seems to us a logical step. There are many unsolved questions that still remain. Is there still a job for ARPA—still very much in evidence—to do? What will become of the Army's Ballistic Missile Agency and the scientific team there which has contributed so many "firsts" in the space field?

The Air Force, incidentally, will probably need and would probably welcome their help—if this isn't heresy. For the Air Force, at the moment, is recognizing the burden of a great responsibility. And is approaching possibly the greatest assignment of its existence with very great humility.

CLARKE NEWLON



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letters

Further on *Seaslug*

To the Editor:

We were very pleased to see in the M/R Missile Encyclopedia (July 20) an account of our *Seaslug* ship-to-air missile. For your records, however, I would point out that *Seaslug* is a beam rider and not, as you state, a semi-active homer. This fact was security-cleared and released after you had gone to press.

John M. Davis
for Publicity Manager
Sir W. G. Armstrong
Whitworth Aircraft Ltd.

Red 'Ball of Fire' Photo A Phony?

To the Editor:

Your photo of a Soviet "Ball of Fire under water" (Aug. 24, p. 24), appears to be either a misinterpretation or a fake. Note that the "coaxial projector" at lower left is obviously illuminated from upper left, by the shadows cast, not from the discharge in front. The discharge itself can be duplicated by an end-on view of other electrodes.

USSR scientists have proved they are capable, but honest scientific theories on ball lightning may readily be embellished by propagandists, as I suspect has been done in this instance, to show amazing but probably non-existent practical results.

The "frequent natural phenomenon" of bead or chain lightning you theorize as possibly pinched-off plasma, I believe is only simply explained visual illusion. If a lightning stroke following the usual erratic path in one vertical plane follows a relatively direct path in another vertical plane rotated approximately 90° from the first, the portions of the discharge path which first appeared to travel approximately horizontally to the right or to the left will appear to advance or recede from a viewer located 90° about the phenomena with respect to the first viewer; and the concentrations of luminous energy at these positions as seen by the second viewer will appear as intensified "beads" or links in a "chain" in the discharge path. This theory can be readily proved by simultaneously photographing lightning strokes by two cameras oriented 90° about the storm center.

Charles C. Littell, Jr.
Engineering Associates
434 Patterson Road
Dayton 19, Ohio

The photo appeared in the magazine Soviet Union and there is no need to expect that the electrode illumination comes from the discharge itself or that the photo was faked. Agreed, in some instances bead lightning can be explained as optical illusions. But it also could be pinched-off plazma phenomenon.—Ed.

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NEW PRODUCT BRIEFS

PECIALIZED RECEIVERS. Nems-Clarke ompany, a division of Vitro Corpora- on of America, announces two new ecial purpose receivers, Types 1905 d 1906. These two equipments are a velation of what can be accomplished miniaturization through employment solid state design, state of the art iniaturized components, and the latest packaging techniques. Standard rack ounting size is 19" wide by 8¾" high. pes 1905 and 1906 are less than half is size with panels 19" wide by 3½" gh by a maximum of 15" deep. A eight reduction of approximately 50% also realized. In addition . . . physical ace economy is enhanced by a greater equency range coverage of 30 to 260 egacycles. Two bands are employed: e of 30 to 60 megacycles, and the her from 60 to 260 megacycles. Type 05 reception is AM and CW, and pe 1906 reception is FM, AM, and W.

The tuners in these receivers are de- gned to produce an extremely low ise figure and incorporate practical ning structures capable of tuning 30 260 megacycles, with uniform per- rmance over the band.

rcle No. 225 on Subscriber Service Card.

LICON-RUBBER ADHESIVE. A new lhesive for bonding RTV (room-tem- erature-vulcanizing) silicon rubber to etal is now available for evaluation om Hughson Chemical Company, A Di- sion of Lord Manufacturing Co. Desig- ited as Adhesive EX-B579-1, it pro- des bonding during the room tempera- re cure of silicone rubber compounds. ibber-tearing bonds are produced ich have excellent environmental resist- ce to broad temperature conditions. is one-part, one-coat adhesive does t stain. Excellent bonds can be ob- ined with a wide variety of RTV silicon bbers to steel, aluminum, brass, copper d other metals as well as glass, porous ramics, cured epoxies, phenolics and her resins, synthetic fabrics and treated flon. Adhesive EX-B579-I is well suited the processing and performance indards of the electronics industry iere RTTV silicones are used for pot- g and insulating of connectors and ner components. Other applications lude aircraft gasketing and sealing.

rcle No. 226 on Subscriber Service Card.

OXY RESIN. Processes for insulating insormers to meet the grades of MIL-T-27A with scotchcast brand epoxy resin are outlined in a new eight-page booklet issued by Minnesota Mining and Manufacturing Co. Sections of the booklet deal with background on MIL-T-27A, transormer design, resin handling and proven processes for applying epoxy resins. The methods outlines include: dip coating, molding potting metal encased units and encapsulating open type transformers.

Circle No. 227 on Subscriber Service Card.

SERVO. A new one-ounce servo motor-generator just introduced by the Daystrom Transicoil Corp. represents an advancement in servomechanism miniaturization. The "size 5" unit, including gearbox, is less than half as big as its smallest predecessor. The unit will undoubtedly find wide use in missile control systems where size and weight are such critical factors. Savings here have compound results: when one component is significantly reduced, then its accessories—power supplies, amplifiers, heat dissipators and insulation—can also be reduced.

Circle No. 228 on Subscriber Service Card.

PRECISION TRANSDUCERS. A new precision Kavlic transducer has been announced by Vinson Manufacturing Company. These transducers were specifically designed to provide unit to unit tracking with a maximum error of .002" over a 1" range. The null position is constant within .001" from unit to unit and varies a maximum of .001" within the temperature range of −65° to +300° F. Other specifications include linearity of ±.15% and sensitivity of .88 V/in V. Secondary impedance is 28 ohms, and recommended input voltage is 8-10 volts @400 cps.

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PNEUMATIC AIR VALVE. Dynamic Controls Corp. has developed and is now producing in quantity a pneumatically operated air valve of extreme sensitivity. The valve will operate from the full open to the full closed position with a change in signal pressure of 1 psi or less, depending on the valve size required. The signal pressure and the controlled pressure are isolated from each other. The unit, which was designed for missile and aircraft application, weighs only 0.3 lbs., but can be subjected to temperatures of 360° F.

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MISSILE LITERATURE

VIBRATION ISOLATION SYSTEM. A new concept in vibration isolation for gyroscope and other delicate navigation equipment has been developed by Allied Research Associates, Inc. The suspension system provides freedom for omni-directional rectilinear motion, but maintains high-stiffness constraint against rotation. With this system, it is possible to eliminate the damaging and error-inducing effects of environmental shock and vibration without compromising the precision of initial angular alignment. The mount exhibits low resonant transmissibility and has its elastic center located so as to decouple translation and rotation. Performance is effective over a wide temperature range. The mount assembly utilizes a unique configuration of metal C-shaped springs to obtain the desired stiffness characteristics. System damping is provided by elastically supported unit dampers which are consistent over a wide system to eliminate hysteresis torques. As a result, precise static alignment of the mounted unit is possible and the error in angular returnability is virtually eliminated. The mount provides shock attenuation, improved vibration isolation at high frequencies, low resonant peaks, decoupled angular and translational modes and angular alignment characteristics. Two configurations of the mount are currently in production and are each incorporated in an aircraft navigation and bombing system. Performance characteristics of each exceed specifications, with one mount featuring an angular returnability of 30 seconds of arc.

Circle No. 200 on Subscriber Service Card.

PLATINUM PRODUCTS. J. Bishop & Co. Platinum Works, has just issued a 20-page platinum products catalog which includes the complete standard line of platinum products, chemicals, recovery and refining facilities of this company, as well as information on clads and composites of platinum group metals with base metals. Reference is made to the items that can be manufactured to customer specification upon request. Clear, clean cup tables for conversion, etc., are included.

Circle No. 201 on Subscriber Service Card.

ELECTRONIC GALVANOMETER. A new bulletin presenting specifications and a complete description of a multi-purpose electronic galvanometer is available from KIN TEL Division of Chou Electronics. Outlined in the bulletin are the operating characteristics and applications of the KIN TEL Model 204A Electronic Galvanometer. The 204A is a chopper stabilized instrument that can be used for current measurements to $2x10^{-11}$ amperes. It is 20 times as sensitive as the mechanical mirrored-type galvanometer and its all-transistor construction makes it much more rugged. The bulletin details the instrument's other uses, such as a DC null detector, a linear deflection indicator, microvoltammeter, and inverting DC amplifier. A circuit diagram and description and tabulated specifications are included to provide complete technical information on the unit.

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LIQUID FUELS COMBUSTION. A com prehensive guide to literature on fu damental research on liquid fuels com bustion has been reprinted and is no being sold by the U.S. Department Commerce's Office of Technical Service Titled "Injection and Combustion Liquid Fuels," the 789 page monograp was prepared originally in 1957 WADC Technical Report 56-344 specialists at Battelle Memorial Institut working under contract with the U. Air Force's Wright Air Developme Center. The monograph covers liter ture, published through 1956, on liqui fuels combustion research. It contains critical review of material in the u classified literature relating directly the fundamental physical phenomena i volved in high-intensity combustors an other steady-flow combustion processe Included are sections on atomization liquid fuels, ballistics and evaporation droplets, laminar flame propagation, tu bulent flames, premixed flames, stabili limits, droplet combustion, diffusi flames, and ignition.

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GRINDING MACHINE. Design fe tures, applications, specifications and a cessories of the new Heald Model 273 Universal Internal Grinding Machine a described in an eight page illustrat two color brochure. The Model 273A a high precision grinder for internal, e ternal and rotary surface grinding. will grind straight or taper bores, ou side diameters, flat, convex or conca surfaces. Developed specifically to the need for a low cost, high precisi grinder, the Model 273A finds its be application where internal grinding of variety of single parts or small lot pr duction is required. The standard Mod 273A has a capacity for chucking a straight or taper grinding outside di meters on work up to 12" O.D. Sin the wheel head can be mounted in se eral positions on the cross slide and wi the variable speed workhead drive—1 to 450 rpm—the Model 273A can hand a wide range of work on shaft, ge bushing, hub and spacer faces and ou side diameters. Besides cup wheel fa ing, the 90° swivel of the workhead the 273A allows periphery wheel grin ing of broad or narrow surfaces. Co cave and convex surfaces can also ground by swiveling the workhead any point up to 90°.

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RECORD READERS. A catalog Benson-Lenner data products defines t term "record reader" and discusses t various types of record readers pr duced by the corporation. The catal discusses special purpose record read which are used to convert informati recorded in pictorial or graphic fo into either digital or proportional anal resistance form. The catalog also d cribes various types of automatic pl ting machines used for graphing bu ness, military and scientific data from variety of inputs invluding punch-car punch-paper tape, magnetic tape, ma ual keyboard and the outputs of aut matic data handling systems.

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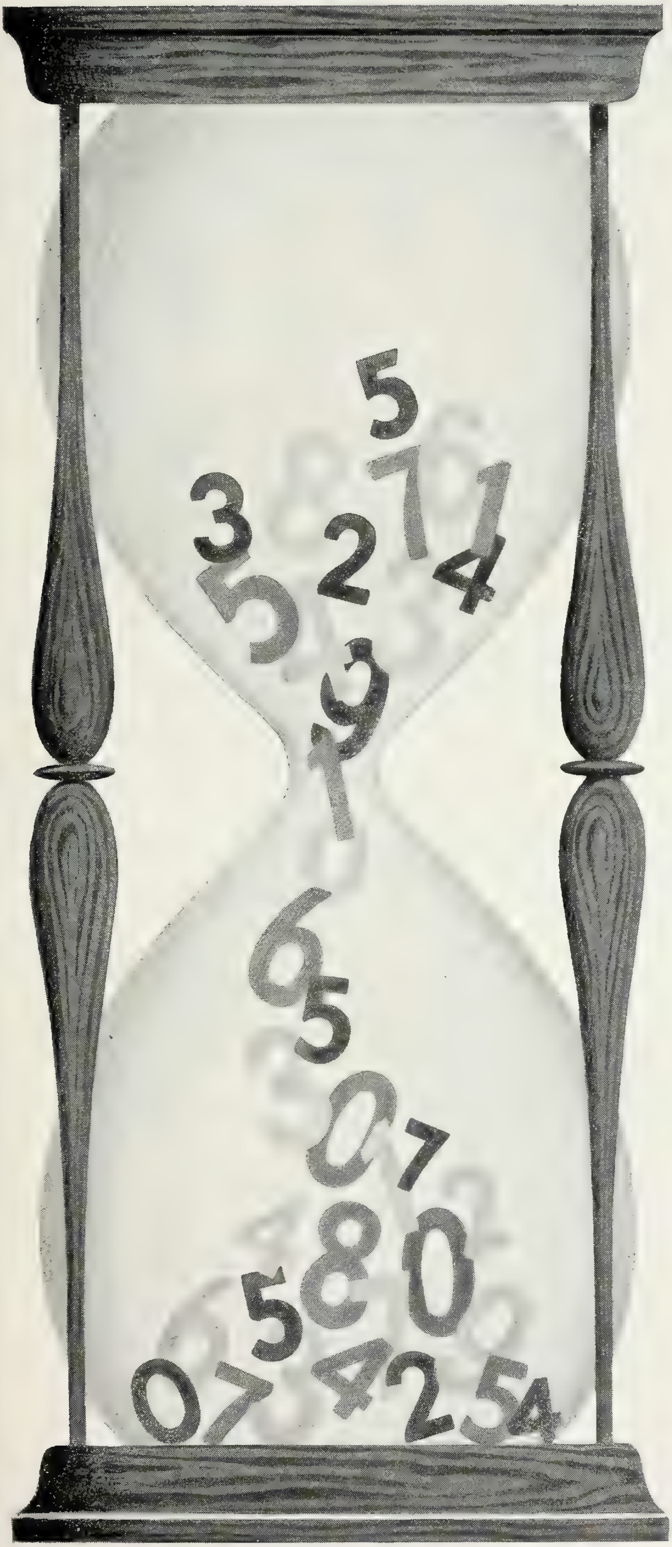

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Drift less than 2 microvolts for 200 hours.
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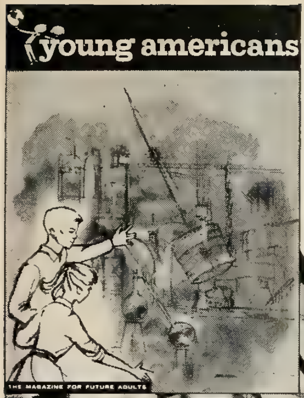

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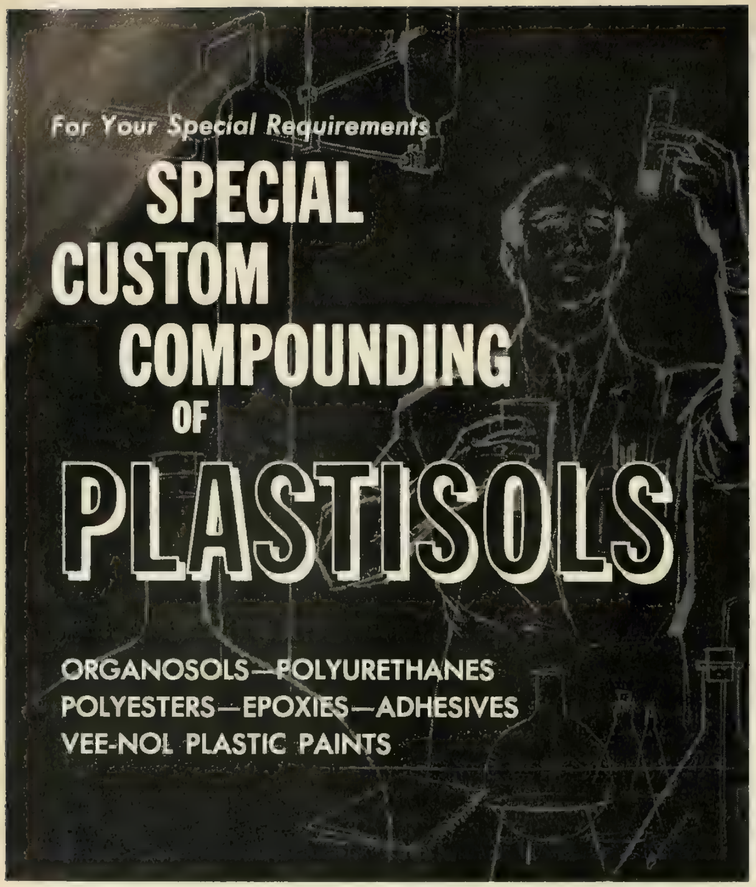

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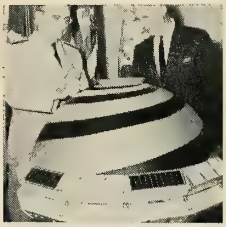
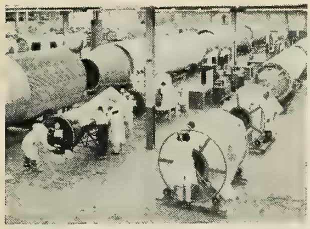
missiles and rockets
MAGAZINE OF WORLD ASTRONAUTICS

30,700 copies of this issue printed

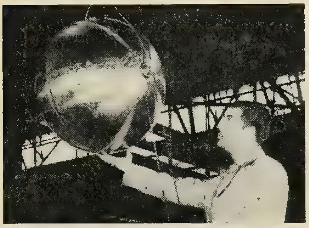
COVER: Ceramic-coated metal used in the exhaust nozzle of the *X-15* engine built by Thiokol Chemical Corp. is subjected to temperatures well in excess of the 5000°F it must withstand.



ANTENNA system of *Transit* R&D model is studied by Rear Adm. K. S. Masterson, Assistant CNO (Development) and Assistant Navy Secretary (R&D) J. H. Wakelin, Jr. See story starting on p. 16.



ARMY'S Michigan Ordnance Missile Plant near Detroit, run by Chrysler, turns out *Jupiters* and *Redstones*, employs 10,000. Auto firms are working to bring in more missile work. See p. 18.



TITANIUM'S first big use in missiles was this 50-lb. helium bottle for the Convair *Atlas*. Titanium and plastic are making inroads in steel's near-monopoly for solid motor cases. See p. 29.

OCTOBER 12 HEADLINES

Air Force, NASA May Compete for ABMA Facilities
But feeling at Huntsville, after initial jolt of Pentagon reshuffle announcement, is that major work will continue regardless of who's in control 15

***Transit* Still Due To Be First Military Space System**
Despite last month's launching failure, the ARPA-Navy project is proceeding on schedule calling for prototypes in orbit by early 1961; but money problems could still bring delays 16

Michigan Fights For Missile Dollars
A state which once was the nation's chief arsenal has fallen out of step in defense work, but motor companies are leading comeback effort. Part I of a two-part survey of the Great Lakes area 18

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The new satellite, slowed and turned back toward earth by moon's gravity should provide a wealth of valuable data 47

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Electric, torch, hot spot, catalytic and hypergolic systems have many uses in repetitive starts. Part II of a two-part survey 20

Ion Rockets Lead in 'Exotic' Propulsion
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These materials may someday form boosters and second stages, although steel is still tops now because of its low cost and familiarity 29

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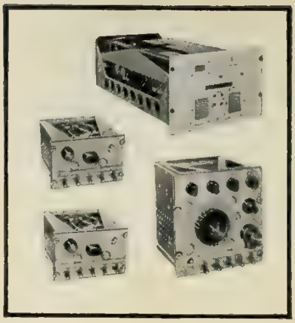

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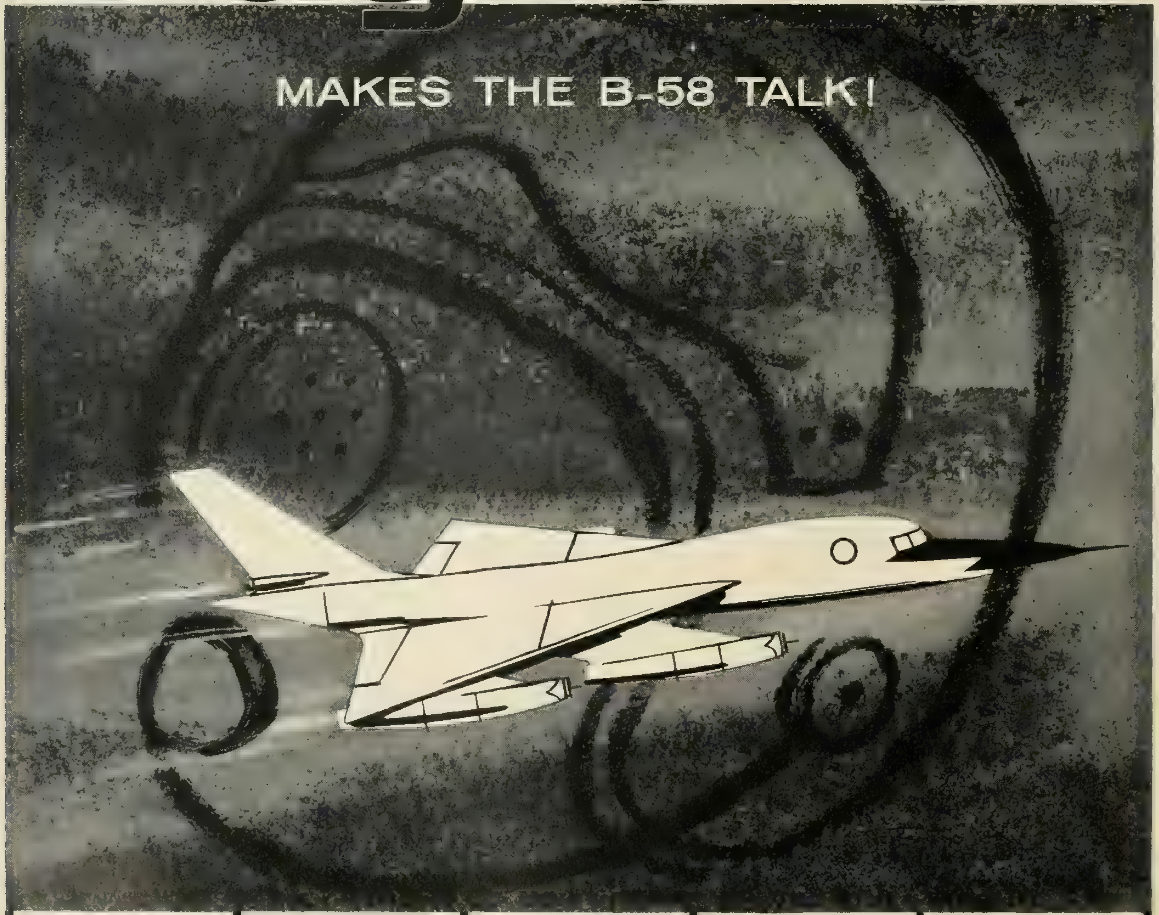
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Washington Countdown

IN THE PENTAGON

Stiffening of ASW . . .

defenses is not far off. **Minneapolis-Honeywell's** *Asroc* is scheduled to be deployed aboard ships beginning next year. Some of the Navy's big new destroyers are expected to get the anti-submarine missile first.

• • •

Deployment of *Subroc* . . .

isn't too much further away, either. The **Goodyear** torpedo-missile is expected to be operational in not much more than a year. It will be put on nuclear-powered submarines for firing from regular torpedo tubes. The Thresher—scheduled to be launched in January, 1961—is expected to get *Subroc* first.

• • •

Discoverer *VII's* launching . . .

now is scheduled for later this month. ARPA planned to launch the R&D satellite late last month . . . then postponed the shot to make further studies. The new launching will be another attempt to recover a capsule from orbit. Again no wildlife.

• • •

A hot new project . . .

has been added to ARPA's portfolio. The highly classified effort is a costly one and is expected to become more so. It is understood to involve both space and the environment of earth.

• • •

Killing enemy satellites . . .

is one of the latest weapon requirements laid down by the Pentagon. The new weapon would be a satellite sweep system capable of finding and destroying enemy satellites. **Motorola** is making a study for the detection system.

• • •

Where the budget ax falls . . .

next is the question of the moment in all three services. The atmosphere may have been best expressed by an official who, when asked if *Dyna-Soar* might be in jeopardy, said: "I don't think so. I looked in on the project officer yesterday and he hadn't hung himself."

The shakeup of ARDC . . .

may not be the end of Air Force readjustments at the present time. It may lead to a complementary shakeup in the Air Materiel Command.

At NASA

An about-face . . .

appears to be in the works at NASA. Informed sources say the agency plans to speed up its programs because of the *Luniks*, and is preparing a supplemental budget for Congress to okay to cover the added cost. NASA earlier this year told Congress it had as much money as it could spend wisely.

• • •

Feverish efforts . . .

already are underway to get another *Atlas-Able* rocket ready to launch a moon-orbiting satellite late this month or early in November. If NASA misses that date, a launching will be attempted in late November. The planned moon-orbiting shot had to be called off early this month after the only *Atlas-Able* that NASA had available exploded.

• • •

The first *Little Joe* . . .

launching is recorded as a complete success. The Project *Mercury* test vehicle's booster, launcher and destruct mechanism performed exactly as planned. The next of five more launchings will test the performance of the *Mercury* capsule during recovery.

AROUND TOWN

A French space program . . .

is expected to get under way shortly. All French non-military R&D is now under the direction of one man—Pierre Piganiol. And he is understood to be planning to spend francs first on space.

• • •

Some of the reports . . .

being passed as "the latest" in the nation's capital:

. . . Loud and long demands for Pentagon reorganization are a sure thing in the coming months.

. . . The next Russian space feat probably will be a soft landing on the moon.

. . . *Samos*—the ARPA-Air Force reconnaissance satellite project—is not showing as much promise as had been hoped.

A UNIQUE APPROACH TO INFRARED GUIDANCE

This precision spherometer measures a unique material developed at Hughes for infrared guidance. It can measure the curvature of the dome's surface to an accuracy of 10^{-6} meters.

The material tested is unique in that it is completely opaque in the visible region, yet transmits very well in the infrared. First application of this material to military equipment requirements was carried out at Hughes.

This project is just one of the advanced studies in all phases of radar, inertial and infrared guidance currently underway at Hughes Research & Development Laboratories.

Assignments in missile guidance now open include:

Physicists to conduct Radiation Detector Studies
E.E.'s for Experimental Circuit Design
E.E.'s for IR Systems Studies
E.E.'s for Servo Analysis and Simulation
Optical Designers

The salary structure for the above positions reflects the advanced nature of the assignments. Please inquire by writing directly to: Dr. Allen Puckett, Assoc. Director, Hughes Systems Development Laboratories.

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Industry Countdown

MANUFACTURING

Scaled-up 10-million-lb. . . .

thrust solid booster is being pushed by **Thiokol.** Company studies show it would be feasible to fabricate at launch-site a 107-ft.-long, 20-ft. diameter vehicle weighing just under 3-million pounds fueled. The huge motor would cost (after development) $3,769,000—about one-third as much as a comparable-size booster by alternative methods. Chief hitch: development might cost $100 million.

• • •

Look for major switch . . .

to non-nuclear warheads for missiles. DOD's strategists see a need for highly effective conventional explosives to maintain the Nation's security if there is nuclear disarmament agreement with Russia or if a nuclear stalemate is reached. R&D of new explosives will be required to yield a "big punch" from a relatively small missile package.

• • •

Big competitor to hydrofoils . . .

as the Navy's high-speed submarine killer is Britain's Hovercraft. **National Research Development Corp.** reps are now in the U.S. telling armed forces how the ground cushion effect vehicle would be less expensive to build than hydrofoils, will go faster (90 knots vs. 45 knots) and doesn't have the deep draft problems of a surface craft.

• • •

X-ray standards . . .

will be established for strength of steel castings by **Convair** for the Air Force. The company did a similar job on aluminum and magnesium castings.

PROPULSION

Lack of million pound . . .

deadweight calibration facilities at National Bureau of Standards is seriously hampering U.S. development of multi-meg-thrust rocket engines. The present 111,000-pound maximum means several steps in calibrating big load cells with consequent loss in accuracy. Design of a suitable unit is in process, but the $1.5 million required to build is unavailable.

• • •

Nuclear systems division . . .

has been established at Van Nuys, Calif., by **Marquardt Corp.** . . . **Republic Aviation** is now using adhesives to join the inner and outer shells of missile engine casings.

• • •

Sea-level propulsion tests . . .

and inadequate telemetry flight data are being blamed for many missile failures. AF Arnold Engineering Development Center says it is overcoming some of these problems with high-altitude test cells.

• • •

Helium shortage . . .

could put the *X-15* engine program in a bind, although tests are proceeding on schedule. AF is now rationing the gas, which is used to pressure *X-15* fuel lines. **Thiokol's Reaction Motors Division,** Denville, N.J., is averaging two tests a day and in the past three years has run 2400 static firings of the engine.

ASTRIONICS

Nighttime recovery . . .

of missile nose cones and space capsules may be possible through discovery that fluorescent dye markers are heat absorbers and can be detected by infrared. In daytime detection range of 1 mile or so is inferior to visual and/or radio beacon methods.

• • •

Permanent missile impact . . .

location center is now under construction by the Navy at Kaneohe Marine Air Station, Hawaii. The center will track *Atlas* training shots from Vandenberg AFB which are aimed in vicinity of Wake Island.

WE HEAR THAT—

Miniature missile parts . . .

made of dissimilar metals are being welded by **Emmco Development Corp.,** Brooklyn, N.Y., with a new electrical "fridg-flash" process . . . The new Carteret, N.J., plant of **American Metal Climax Inc.** will produce germanium for the electronics industry . . . **F. J. Stokes Corp.,** Philadelphia, is building a $250,000 cold-wall vacuum heat-treating furnace for **Convair.** It will be used for heat treating alloy steels at temperatures up to 2150°F. . . . **Leeds & Northrup Co.** has opened a new $2-million research center at North Wales, Pa. . . . A research and development subsidiary will be opened in Florence, Italy, by **Melpar, Inc.,** Falls Church, Va.

More About the Missile Week on Page 43

AiResearch gas turbine completes 5,000 start cycles

Reliability Record Achieved Under Tough Test Conditions

Air Force trailer-mounted MA-1A starter cart with improved AiResearch GTC 85-20 gas turbine unit.

AiResearch engineers inspecting improved AiResearch GTC 85-20 gas turbine unit after successful 5,000 start cycle test.

A world performance record for small gas turbine reliability has been established by this improved AiResearch GTC 85-20 unit . . . 5,000 start cycles. During each start cycle the turbine was brought to peak load twice, with a shut down time of only five minutes. This is equivalent to two main engine starts per cycle.

Throughout the entire test only routine maintenance was necessary plus replacement of one generator brush. AiResearch gas turbines now in production incorporate the improvements made in this newly tested unit.

Pneumatic power source for the Air Force's trailer-mounted MA-1A starter cart, the engine was torn down under supervision of Air Force personnel from Wright Air Development Center. It is now undergoing further tests upwards of 10,000 start cycles.

This intense product improvement in gas turbine reliability is matched only by AiResearch versatility. The world's largest manufacturer of lightweight turbomachinery, AiResearch has designed, developed and produced more than 8,500 gas turbines of all types vital to military and commercial ground support as well as auxiliary and prime power applications. Your inquiries are invited.

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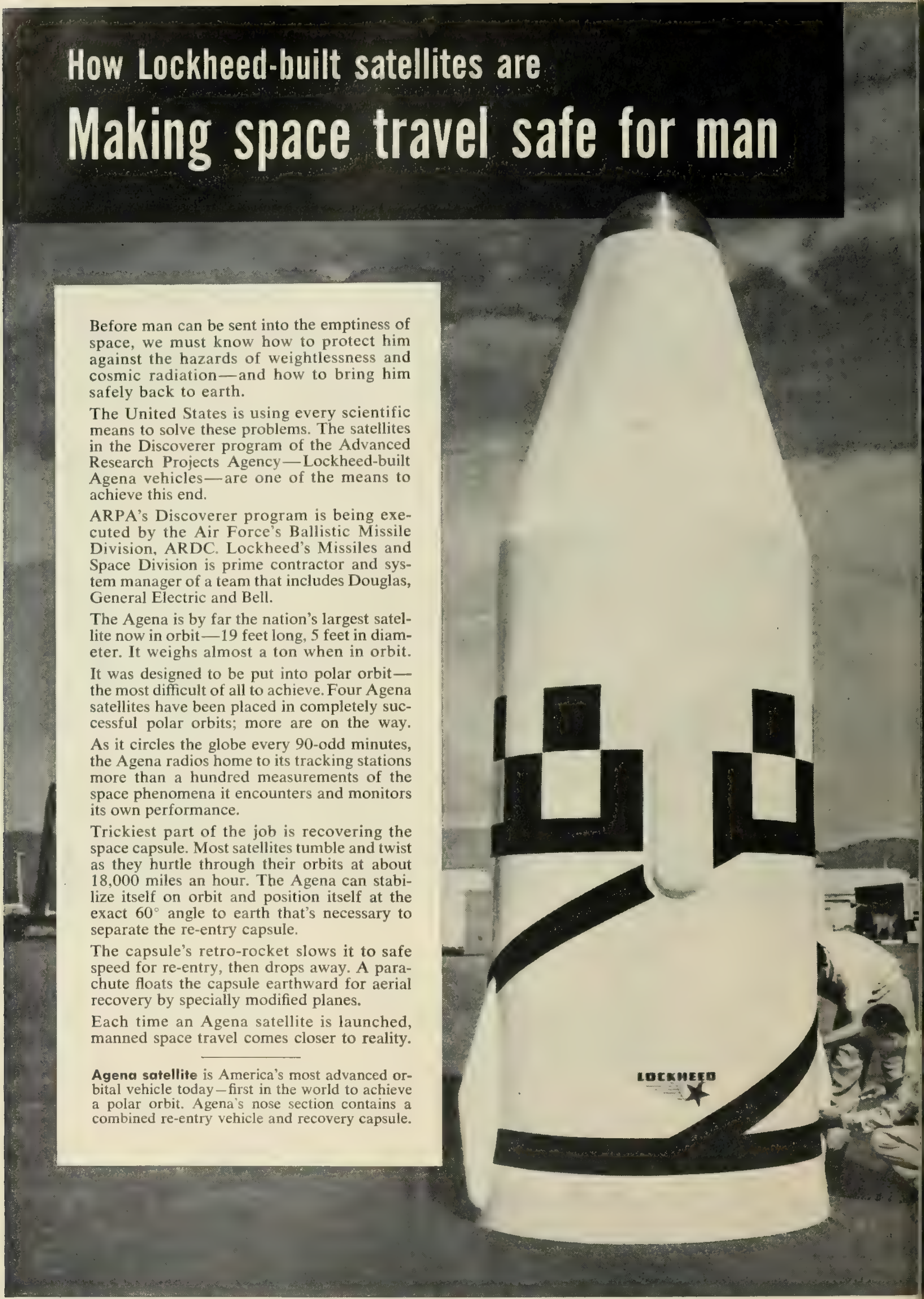
How Lockheed-built satellites are

Making space travel safe for man



Before man can be sent into the emptiness of space, we must know how to protect him against the hazards of weightlessness and cosmic radiation—and how to bring him safely back to earth.

The United States is using every scientific means to solve these problems. The satellites in the Discoverer program of the Advanced Research Projects Agency—Lockheed-built Agena vehicles—are one of the means to achieve this end.

ARPA's Discoverer program is being executed by the Air Force's Ballistic Missile Division, ARDC. Lockheed's Missiles and Space Division is prime contractor and system manager of a team that includes Douglas, General Electric and Bell.

The Agena is by far the nation's largest satellite now in orbit—19 feet long, 5 feet in diameter. It weighs almost a ton when in orbit.

It was designed to be put into polar orbit—the most difficult of all to achieve. Four Agena satellites have been placed in completely successful polar orbits; more are on the way.

As it circles the globe every 90-odd minutes, the Agena radios home to its tracking stations more than a hundred measurements of the space phenomena it encounters and monitors its own performance.

Trickiest part of the job is recovering the space capsule. Most satellites tumble and twist as they hurtle through their orbits at about 18,000 miles an hour. The Agena can stabilize itself on orbit and position itself at the exact 60° angle to earth that's necessary to separate the re-entry capsule.

The capsule's retro-rocket slows it to safe speed for re-entry, then drops away. A parachute floats the capsule earthward for aerial recovery by specially modified planes.

Each time an Agena satellite is launched, manned space travel comes closer to reality.

Agena satellite is America's most advanced orbital vehicle today—first in the world to achieve a polar orbit. Agena's nose section contains a combined re-entry vehicle and recovery capsule.

Boosted into space by the 150,000-pound thrust of an Air Force Thor missile, the second-stage Agena satellite is powered into orbit by its own liquid-fuel rocket engine of 15,000 pounds thrust.

Once in orbit, the Agena satellite radios back to its tracking stations more than a hundred measurements of its performance and of the conditions it encounters as it circles the earth at 18,000 mph.

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RAMJET PROPULSION TESTING

RYAN FIREBEES STAR AGAIN AT SECOND "WM. TELL" MEET

The Air Force has selected Ryan Firebees as the exclusive targets for Project "William Tell II"—the second annual world-wide weapons meet to use free-flying jet targets for the purpose of testing pilots, planes, and missiles.

The Ryan Firebee—America's most widely used jet target and the hit of "William Tell I"—provides the most economical and realistic means of maintaining air defense weapons at combat readiness. Firebees stay "on station" for extended periods—permitting numerous attack sorties. And they can be used over and over again.

Pitted against the Firebees will be the top Air Defense Command squadrons, flying Convair F-102, Lockheed F-104, Northrop F-89 and North American F-100 interceptors. They will fire deadly Falcon and Sidewinder guided missiles and Genie (atomic-type) rockets.

The advanced, new transonic Q-2C Firebee—now in production for the Air Force—has already set world's records by flying faster (mach .95), higher (59,800 feet), and longer (99½ minutes).

Ryan has led the field in the design, development, and production of jet target missiles for more than ten years. The Firebee is another outstanding example of Ryan's skill in blending aerodynamics, propulsion, and electronics knowledge to produce a superior product.

RYAN OFFERS CHALLENGING OPPORTUNITIES TO ENGINEERS

RYAN BUILDS BETTER

AIRCRAFT • MISSILES & COMPONENTS • ELECTRONICS

Ryan Aeronautical Company, San Diego, Calif.

Air Force, NASA May Bid for ABMA

Uncertainty clouds the future control of Redstone but there's confidence it will stay in business regardless of ownership; some welcome idea of AF takeover

by an M/R Correspondent

HUNTSVILLE, ALA.—With the Air Force taking "eventual" control of all space transportation, who will boss the Army team which pioneered America's venture into outer space?

That's the big question in Huntsville today, and no one seems to know the answer—not even Secretary of Defense Neil H. McElroy.

McElroy told a former Huntsville newsman in Tokyo last week that "special and urgent examination" is being given by the Defense Department to utilization of the Redstone Arsenal space team headed by Dr. Werner von Braun.

He also gave a hint as to how the decision might go: "The basic approach is that these fine, capable people must be used to the best advantage of United States programs on space and advanced techniques. The best way will be worked out. It may be a combination of work for the military and the National Aeronautics and Space Administration. Exactly how this will be done is being given special and urgent examination."

• **Pulling and hauling?**—Authoritative speculation here and in Washington is that there's likely to be a behind-the-scene tug of war between the Air Force and NASA, although the latter agency reportedly has some doubts as to its ability to fund the 5500-man ABMA at its present level.

Officially, NASA has said that it has no plans to renew its bid of a year ago to take control of ABMA facilities, but the recent Pentagon space program reshuffle may have changed that.

Sen. John J. Sparkman (D-Ala.) says that the issue may eventually have to be decided by President Eisenhower. Another source says it may be decided by the National Space Council, slated to meet in Washington later this month.

Not all of the talk concerns NASA or the Air Force. Some strong Army boosters are hoping that the Army will be allowed to continue operation of ABMA, contracting services to the other branches and agencies. But they admit this is a faint hope at best.

The people most directly affected by any change—the members of the ABMA team itself—are not talking. Washington reportedly has put the clamp on any public comment, and too, there's a general "wait and see" attitude on the part of team members, including Von Braun. "We might be talking about our future bosses if we said anything about anybody," one laboratory chief said.

• **Quick recovery**—News of the ARPA reshuffle caused an initial shock, which quickly dispersed with immediate reports that ABMA would continue to operate, whoever had control.

It was quickly pointed out that of the total force of 22,000 employes at Redstone, only ABMA's 5500 would be involved in the shift. Employes of the Army Rocket and Guided Missile Agency and the Ordnance Guided Missile School would not be affected. And even some of ABMA's 5500 will surely remain with the Army. ABMA is developing *Pershing* and still has some *Jupiter* and *Redstone* work, along with its major of *Saturn*. Also, several space assignments, including a series of *Redstones* for Project *Mercury* and two *Juno II* space probes, are in the ABMA mill.

Another major factor in easing local concern was the point that ABMA's centralized, unique and compact facilities are unequalled anywhere in the nation, and "they cannot be moved." Examples are the huge 15-story static test stand already modified for the *Saturn* cluster, and the expensive and complex laboratories and test buildings especially designed for development of large rocket vehicles, along with their experienced technical force.

• **Change for the better?**—Apparently, the space team is ready to accept a change in management. Many of them have considered a change inevitable since Secretary of Defense Charles E. Wilson's roles and missions order of Nov. 26, 1956, when he took the Army out of long-range missile operations.

And there is quiet talk that a change will be for the better, especially if the uncertainty of the past three years—during the Air Force-Army controversies—is ended. From the few qualified comments which can be heard, there appears to be some genuine hope that the Air Force will move in and turn the team loose full force on outer space problems.

There are some, especially among the former German members of the team, who have expressed a hope that they could work on "peaceful" projects for space exploration, possibly under NASA. But they voice a fear that NASA couldn't fund their efforts as well as a military service might.

• **The community's stake**—The question of control is of primary interest to all of Huntsville, and not just the ABMA members. The city, with a population of about 70,000, has a substantial economic stake in the space effort. In addition to the Arsenal employes, there are several thousand on the payrolls of satellite industries, such as **Chrysler Corp.**, which has a force of about 800 here to render engineering services. **Brown Engineering Co.** has about 650 doing a similar job, and most of the efforts are centered around ABMA.

However, contractors not expected to be affected, except affirmatively, are those like **Thiokol Chemical Corp.**, which employs about 2000 at its Redstone Division, and **Rohm & Haas Chemical Co.**, which has about 250 employes. Both firms do development work for all three armed services.

Only one official spoke out against the transfer. The city's colorful mayor, R. B. Searcy, said "It is incredible to me . . . that the Army has been kicked out of the space field. The whole world knows that the U.S. Army put up the first free world satellite, put the first made-in-the-U.S.A. satellite around the sun, and kept the free world in the race for space.

"As a reward for this magnificent and indisputable record, the Department of Defense not only umpires the Army out of the ball game, but steals the balls as well."

despite recent failure . . .

Transit System Is Due By Early '61

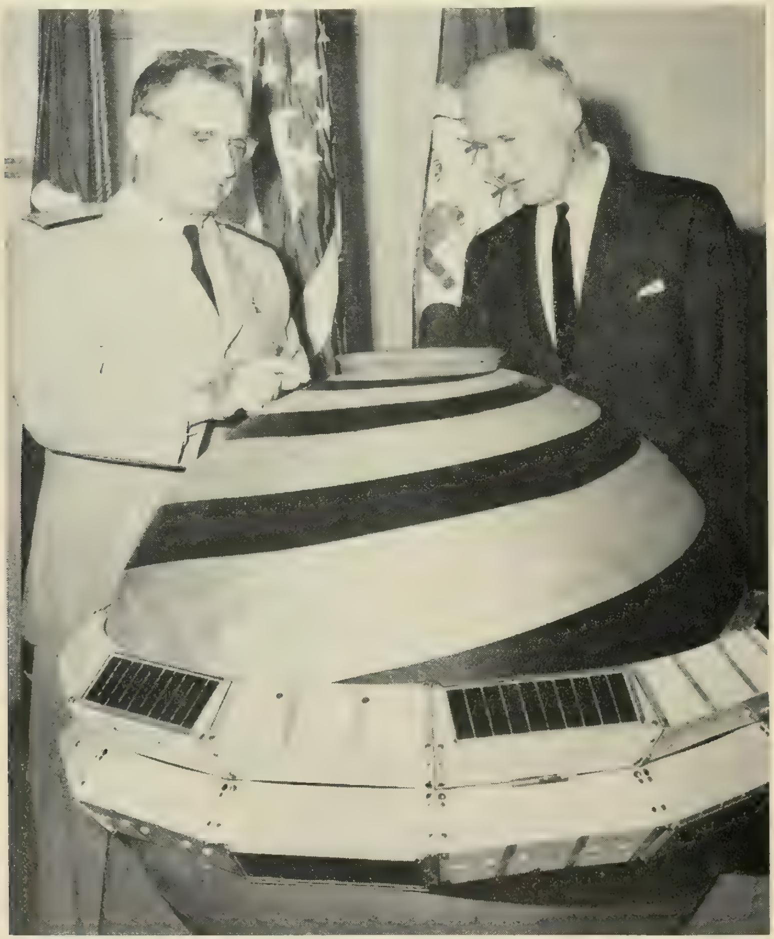
Navigation satellites needed to launch Polaris and ALBM's; new failures could delay program because of money shortage

by James Baar

WASHINGTON—The vitally important *Transit* navigation satellite is still expected to be the nation's first military satellite system despite last month's launching failure.

However, another failure in a row at this time could throw it months off schedule unless more money or boosters from some other project are thrown into the program.

The ARPA-Navy *Transit*—like the bulk of the Pentagon's space and missile programs—is slowed by money shortages. At best, additional funds would bring the system to operational status months sooner. At worst, they would guarantee that it would be operational on schedule.



R&D *Transit* is more than five times the size of planned operational models, to provide redundancy. Antennas are painted on its skin, and its waist is girdled by 12 banks of solar cells. Rear Adm. K. S. Masterson, Deputy CNO for Development, and James H. Wakelin, Jr., Assistant Navy Secretary for R&D, examine satellite.

The early development of *Transit* is no accident. It will play an important part in the *Polaris* system as well as later in the launching of **Douglas** *ALBM's* from bombers.

The first *Polaris*-launching submarine is scheduled to be on station in the last months of next year—possibly as early as September. The *Transit* schedule calls for having the first prototype satellites in orbit only a few months later.

The first spiral-striped *Transit* test satellite was scheduled to go into orbit last Sept. 16. However, the third stage of the *Transit Thor-Able* booster failed to ignite and the 265-pound satellite with the stage attached crashed in the Atlantic southwest of Ireland.

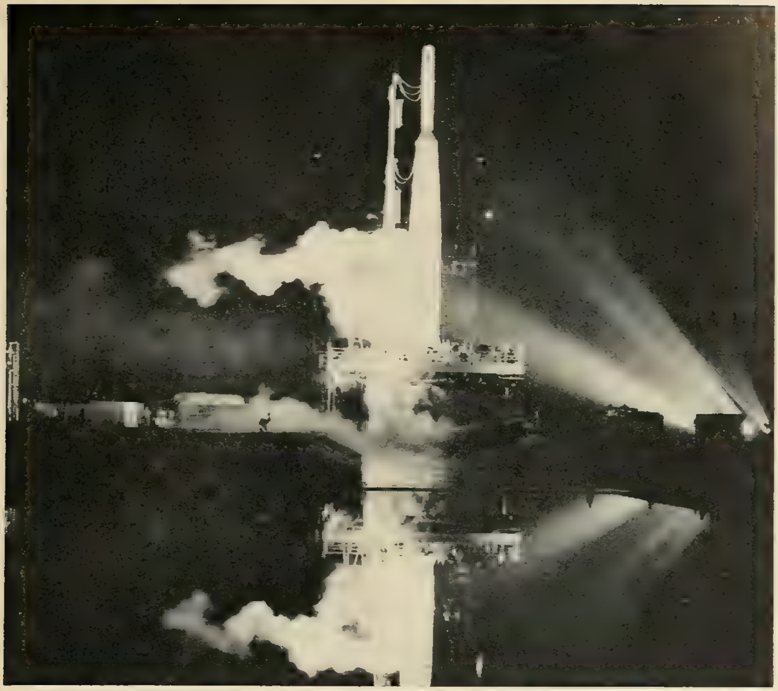
Monitoring stations picked up some data from the satellite's two transmitters during its brief flight. But they only received enough to encourage top scientists in the program in thinking that the design appears feasible.

• **Scanty funding**—The next launching now is scheduled for late winter. Two or three more shots with backups would be spread out during the rest of next year. Finally, two prototype 50-pound *Transits* probably would be launched during the first half of 1961 if the schedule is maintained.

The transit program probably will be turned over to the Navy about the time the prototypes are launched.

In all, ARPA expects to spend about $20 million on the program during the next two fiscal years. That makes it one of the cheapest of the military satellite systems. For example, the *Samos* reconnaissance satellite has a $100 million budget in FY 1960.

Obviously, the *Transit* budget provides slim room for making up for



Thor-Able **three-stage rocket is being used in the** *Transit* **program to launch the satellites into 400-mile orbits. The next launching is scheduled for late winter.**

losses. Additional funds would have enabled ARPA to attempt another launching this fall rather than wait until nearly the end of winter.

• **What it will provide**—The final *Transit* system will involve four 50-pound satellites probably placed in about 400-mile orbits. They will have a life-span of about five years.

A ground station will transmit to the operational *Transits* their exact orbits for each 24-hour period. The data will be stored on magnetic tape in digital computers and transmitted continuously on two stable frequencies.

A ship will be able to obtain the data from one of the satellites at any time over special receiving equipment. There will be no need to interrogate the satellite.

The ship's receiving and computing equipment also will be able to measure the Doppler shift of the satellite's signal, thereby enabling the ship's navigator to know his precise distance from the satellite. This combined with exact knowledge of the satellite's orbit will give the navigator a precise fix on his position.

The system will provide all-weather, global navigation. Navigational fixes obtained from it eventually will be better than two-tenths of a mile—about as precise as the **Sperry** Ships Inertial Navigation System (SINS) developed for *Polaris* submarines.

This also is more than coincidence. *Transit* will provide a precise check point for SINS which must be corrected periodically because of gyro drift.

• **Aiding** *Polaris*—*Polaris* submarines on station will be able to pick up fixes from *Transits* without surfacing. However, a whip antenna must be exposed. Such antennas can be sent to the surface on small floats or even buoyant antennas can be used.

Such precise fixes only become important for plotting trajectories prior to launching missiles. Otherwise, much less precise navigation systems are more than adequate.

Similar fixes would be important for bombers carrying *ALBM's* and surface ships if they are used to carry *Polarises*.

The *ALBM* launching problem is more complex than the problem presented by ships because the high speed of bombers introduces a new factor. One solution is the possible greater miniaturization of computers so that a computer of sufficient capacity to handle the problem can be installed on the planes.

Some officials hope to have *ALBM's* for deployment on B-52's and B-58's by the end of 1962. Air-breathing **North American** *Hound Dogs* are expected to be deployed on B-52's next year.

Therefore, the major defense role of *Transit* is clear.

In no case will its failure to be developed on time badly cripple part of the nation's future retaliatory forces. But certainly it can be said that much assurance for the accuracy of those forces rests on the development of a small spiral-striped ball weighing only 50 pounds.

NATO Nations Lack Space Funds, Would Like Scouts

AACHEN, GERMANY—Europe's lack of funds for any major space exploration programs was pointed up here recently during a round-table discussion of the NATO Advisory Group for Aeronautical Research and Development (AGARD).

The chairman, Dr. Theodore von Karman, and several other speakers indicated that under the circumstances it would be desirable to use NASA's *Scout* vehicle for European space research work.

Dr. M. Freson, of Belgium, suggested to the AGARD symposium that a working group be set up to help small nations with their space projects. Dr. van der Holst, of the Netherlands, said his country's main effort in space research is in the field of astronomy and astrophysics.

Dr. Hugh L. Dryden, NASA Deputy Administrator, disclosed that in 1960 his agency will launch 100 *Aerobee* high-altitude research rockets, in addition to firing a large number of five-stage *Javelins* under the re-entry heat research program. Later, Dryden said, NASA will begin a program involving *Iris*, a vehicle capable of carrying a 160-pound payload to an altitude of 200 miles.

Largest Radio Telescope Is Nearing Completion

SAN DIEGO—The world's largest radio telescope—an installation measuring two miles long and 800 feet across—will be able to locate space noise with greater accuracy than ever before. Located in a desert dry-lake bed 90 miles from San Diego, the system is to be completed in about three months.

Convair Division scientists, who built and operate the massive complex, have observed bursts of solar radiation on outer fringes of the sun's corona.

Using the earth as its "pedestal", such a huge telescope could be built as a movable parabolic reflector only at the cost of many billions of dollars. The system operates at a frequency of 26.3 mc and has a fan-shaped beam width of about one-fourth degree. It will be able to look billions of light-years into space and is expected to help astrophysicists answer many of the questions concerning the emission of radio noise by stellar bodies.

First of a series . . .

Michigan Seeks Missile Comeback

M/R regional survey shows Nation's top arsenal in Korean War has slumped from defense picture; motor companies push hard for missile contracts

by William E. Howard

DETROIT—Much soul-searching is going on in Michigan these days. In the midst of a general upsurge in missile/space production and research in the Great Lakes area, the state inexplicably finds itself far out of step.

Just six years ago, during the Korean War, more than 42% of Michigan's population—some 2,694,000—was employed in factories. Michigan companies held the highest percentage (17.2%) of defense contracts in the nation. **General Motors** alone had $1.9 billion in military work and 95,000 defense workers, highest for any single corporation in the country.

Today, Michigan's share of military contracts has shrunk to a vestigial 3.2%—half of what it was last year. GM's defense business has plunged to about $390 million this year and much of it is being done outside the state. In mid-September, unemployment stood at a depressing 275,000—9.4% of the total work force. Upwards of 150,000 of this number were defense workers.

What's the matter? What can be done to improve the state's economy? These questions have had Congressmen, state officials and economists muttering to themselves for months. They also have been speaking out loud, demanding help from the Federal government, and, perhaps more important, suggesting direct action within the state.

An M/R survey of prominent Michiganders concerned with the problem shows they feel, generally, that manufacturing interests have been too slow to move into the missile/space field. These manufacturers lost ground while they were wholly occupied turning out conventional armaments during the Korean War. Small firms elsewhere in the country during those years were moving into the new rocket and electronic technologies.

When the dramatic switch to missiles started right after the war, many Michigan companies were left at the post. Today they are struggling uphill to win a share of the market. And there is a spreading conviction that the state's economic future lies in space technology.

In a study "What's Ahead for Michigan," the W. E. Upjohn Institute for Employment Research says: "Although Michigan has not done as well as other areas in aircraft and missile parts industries, their good growth prospects plus the need for accurate machining to close tolerances for many of the parts required by these industries suggest that Michigan may be able to secure a larger share of this business . . ."

A survey by Sen. Philip A. Hart (D-Mich.) shows the state's tooling and machining industries have been hardest hit in a downward trend that started in 1957 and is continuing. Geared for mass production, chiefly in the automotive field, the many manufacturing facilities have been slow to shift over to small-scale production of highly specialized items required in rocketry.

• **Short-changed**—What bothers Hart and other members of the Michigan Congressional delegation is a firm conviction that their state is getting short shrift from the Federal government under special programs for awarding defense contracts.

For example: although the state's unemployment is 12% or higher in Detroit or Flint, Hart says Michigan ranks ninth in the value of contracts awarded under the labor surplus area provision of the Defense Act. Against $13.6 million allocated to New York, which was tops between July 1, 1958, and March of this year, Michigan received a paltry $1.5 million under the Office of Civil Defense Mobilization program.

In the Small Business Administration set-aside program, New York again led the states, receiving $435 million between July of last year and

CHRYSLER-OPERATED U.S. Army Michigan Ordnance Missile Plant near Detroit turns out *Jupiters* and *Redstones* on parallel production lines employing 10,000 workers.

April, 1959. Hart says Michigan was 10th—getting just $58.7 million. His survey shows that out of a possible 1500 small businesses capable of participating in the SBA program, actually only 80 received any benefits.

"The hard figures demonstrate only too graphically that these programs are a total failure as far as Michigan is concerned," an economic advisor to the senator told M/R.

"We know that around 90% of defense contracts are negotiated. So it is patently obvious in our case that all the crowing about designating defense work by areas comes after the fact—not before. Otherwise Michigan would be gettting more of it."

Hart feels, too, that there has been a poor utilization of universities, R&D firms and other scientific facilities in the state. The University of Michigan, which participated with **Boeing** in developing *Bomarc,* for instance, has only a few hundred thousand dollars in research contracts—including $267,000 with the Army.

• *Jupiter* **finished?**—While the Wolverine State's missile picture is not entirely framed in gloom, there are several large question marks as to the future.

Take the Air Force *Jupiter* IRBM and Army *Redstone* 200-mile surface-to-surface missiles. **Chrysler Corp.** is prime for both and today is facing the prospect of a complete washout of both programs. The Army wound up *Redstone* buying on June 30 and the Air Force has reached the "buy-out" stage on *Jupiter*.

NASA in August ordered eight *Redstone*-type boosters worth about $3 million for the *Mercury* man-in-space project and is thus keeping the program alive. There has been considerable speculation that either *Redstone* or *Jupiter* may be purchased in quantity as a target for the Army's *Nike-Zeus* A-ICBM—if the Defense Department decides to move ahead with a full-scale *Nike-Zeus* program. This decision is expected before the end of the year.

The Army's Detroit Ordnance District—major missile procurer in Michigan—says a total of $477.8 million has been obligated for both *Redstone* and *Jupiter,* which was an Army missile until it was transferred last year to the AF.

Chrysler has 10,000 employed at its missile division. Its 1559 suppliers and 13 subcontractors employ another 17,100, making a total of 27,100 persons working on Army missiles in the state.

By the end of FY 1960, the Ordnance District says, "total funds awarded to missile contractors by the District will be a half-billion dollars." Just how this money will be distributed over the the next nine months has not been divulged.

The District also has been making substantial buys of missile support equipment. But Sen. Hart's survey shows that much of the mobile equipment purchases—largely because of diversification within the automobile industry—is going to plants outside the state.

• **The brighter side**—The outlook is promising for the state's other prime missile system, the $100 million air-to-air Navy *Eagle* being primed by **Bendix Aviation's** Ann Arbor division, which employs several thousand persons. One drawback is that much of the major work presently is being subcontracted outside the state. But opportunities are being created for local vendors.

Borg-Warner Corp.'s Ingersoll Division at Kalamazoo is turning out metal motor parts for *Nike-Hercules* and JATOS. And it is engaged in substantial support work.

Dow Chemical Co., Midland, developer of the first die-castable alloy of the magnesium-thorium group for service above 500°F, is a principle subcontractor for the *Nike-Zeus*. A major producer of missile/space basic materials, Dow recently formed a new division at Midland for fabricating magnesium, aluminum and other metals.

Aeroquip, located at Jackson, is expanding its plant facilities and is building a special laboratory for testing advanced missile components developed at its engineering center. These include flexible hose assembles, detachable reusable fittings and self-sealing couplings.

Ford Motor Co. is planning to back up at Detroit its new **Aeronutronic Division** at Glendale, Calif., which is prime for the Army's *Shillelagh* short-range surface-to-surface missile and hopes for "large-scale participation in the nation's space and missile programs."

Things are looking up, too, in astrionics. **Burroughs Corp.,** employer of several thousand persons at its Detroit headquarters, recently acquired a $9 million follow-on contract for 36 additional SAGE computer units. This brings Burroughs' total SAGE business to $155 million. The company has made 58 installations of its AN/FST-2 data processing and computer devices throughout the continental United States for the semi-automatic ground environment system for air defense. A network of some 200 separate installations is planned for the system. Burroughs also has the guidance for *Atlas* under a $77 million AF contract.

AT LEAR'S INC.'s new instrument plant in Grand Rapids, workers build gyros in specially designed "clean rooms."

Last month **Lear Inc.** dedicated its new $5-million instrument manufacturing facility at Grand Rapids. The 172,000 square foot plant doubles the company's operation there and brings employment to 3500. Lear is a principal subcontractor for the *Nike-Zeus's* stable platform and is a precision component supplier of several other missile guidance systems.

Many officials are looking hopefully at General Motors to help the state make a comeback in missile/space systems. GM's principal missile activity today is in its **AC Spark Plug** Division at Milwaukee, where the all-inertial guidance for *Titan, Thor* and *Mace* is being manufactured in a $100 million-a-year operation.

In a bid for more missile business, GM earlier this year moved Harold R. Boyer, head of the Cadillac Tank Plant at Cleveland, into the newly-created post of director of military production.

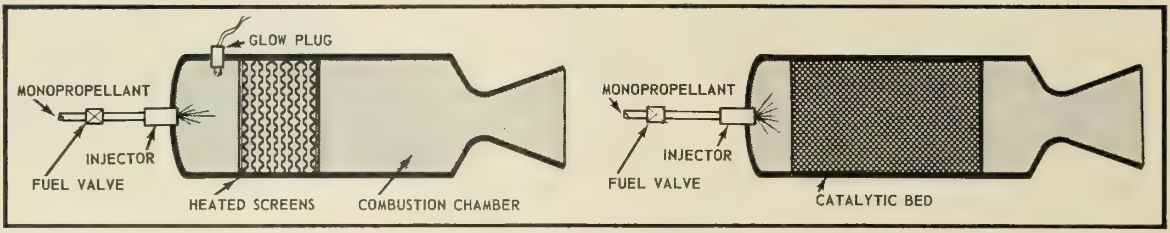
Since the changeover, GM has developed a major proposal with **RCA** for a multimillion-dollar mobile railroad launching platform for the **Boeing** *Minuteman.* Several other teams are in the competition.

GM also has several smaller proposals in the fire and wants to become a prime missile/space systems contractor in the future.

In Michigan today moves are afoot to make manufacturers, particularly smaller ones, more aggressive in the search for new missile business. As one economist puts it: "I think it is pretty evident that for the past several years many of our companies have grown accustomed to being handed business. They have to wake up and get reoriented to selling their capabilties in the missile field."

Demand for Non-Pyrotechnic Ignition

Electric, torch, hot spot, catalytic and hypergolic systems find many uses in repetitive starts—Part II of a two-part series



TWO FAMILIAR types of non-pyrotechnic ignition systems. Left: The hotspot or heated wall ignition. Right: Catalytic bed ignition. Biggest advantage of these types over pyrotechnic devices is their capability for repetitive starts and need for less special handling.

by Frank G. McGuire

Los Angeles—Although pyrotechnic devices pretty well dominate in the ignition of modern missiles and rockets, there's a big market for a wide variety of other approaches—electric systems using spark plugs, glow plugs, inductive and capacitive methods; torch systems; hot spot (heated wall) systems using glow plugs, heat sink, low-voltage AC or DC, and torch igniters; and the catalytic and hypergolic systems.

This demand is expected to continue, because pyrotechnics, appropriate as they are in ignition, have a number of disadvantages: they can provide only single, not repetitive, starts; they require special handling and inclusion of safe/arm devices; they have limited storage life; they are, to some degree, sensitive to temperature; and they offer only a short period of operation.

The other systems described below are employed to get around some of these shortcomings—especially to supply repetitive starts.

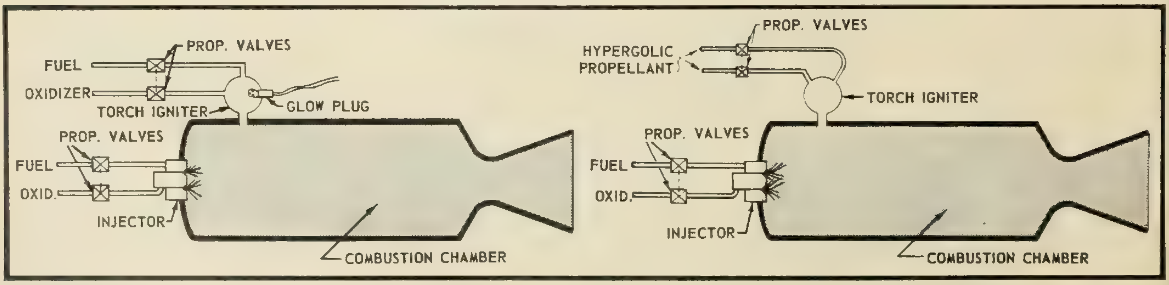
- **Electrical systems**—Electrical ignition systems have, of course, been used in aircraft, automotive and rocket systems for years. Because they must operate continuously in some systems, their weight has been accepted in the design of vehicles. But problems arise from the nature of their operation: erosion and fouling of electrodes, erosion of breaker points, timing, high-voltage insulation and radio interference are some of them.

The development of diesel engines brought forth the glow plug as a method of ignition. The low voltage used in a glow-plug system sidesteps the high tension problems of spark plug systems. Jet engine systems, although not requiring timing of a spark, pose other problems in common with reciprocating engines, as well as additional difficulties brought by high-altitude ignition and severe weight limitations.

Even more stringent requirements have been introduced into missile and rocket systems by the extreme environmental and operating characteristics of these vehicles. They need lower voltage, lower weight, both extremely high- and low-pressure starting systems, and special types of igniter units. Each system has its own requirements.

A continuous development program between electrical ignition system manufacturers and **Aerojet-General Corporation** resulted in a number of improvements that enabled electrical systems to meet the needs of rocket engines. Some of the ignition system manufacturers included **B G Corp., General Lab Associated Corp., G.L.A. Inc., Champion Spark Plug Co., Auburn Spark Plug Co., Bendix Aviation Scintilla Division,** and **AC Spark Plug Co.**

Among the many improvements



REPRESENTATIVE OF THE torch ignition systems are, left, bi-propellant starter, and, right, hypergolic propellant starter. Many types of gas generators use these systems to ignite and decompose the monopropellant fuel. Disadvantage of hpergolic ignition is the restriction on fuel types.

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Astronautics Division. Concentrating on advanced vehicles for space exploration and on ballistic and anti-ballistic missile systems. Supplying four-stage *Scout* research rockets and launchers to NASA. Participation in the competition for the development of the *Dyna-Soar* boost-glide vehicle.

Electronics Division. Developing, manufacturing, marketing military systems including antennas and related electronics, ground support electronics, and antisubmarine apparatus.

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were reduction of weight from 2-3 pounds to 3 to 11 ounces; improved low-tension systems (high tension being 5000 volts and above, low tension being 2000 to 3000 volts); development of capacitor discharge systems to prevent plug fouling; development of better semi-conductor spark plugs; improvement of glow plugs and their high-temperature sealing methods; development of anti-fouling spark plugs and high-tension systems.

Semi-conductor gap plugs were developed to obtain a longer arc by using a larger gap between the electrodes; good semi-conductor plugs have a resistance of between 200 and 2000 ohms. Application of a surge voltage across the electrodes will ionize the surface of the semi-conductor and the area of air surrounding it, providing a path for follow-through current to burn off and ignite accumulations of carbon and fuel between the electrodes.

- **Glow plug igniters**—Two types of glow-plug igniters are in use—with shielded and unshielded elements. Glow plugs have the advantages of repetitive and continuous operation, low weight and small construction, and a good thermal mass for ignition source. Their disadvantages are element burnout, low response time, lower temperature than spark ignition, and, unless shielded, susceptibility to fouling or shorting.

The shielded-element type offers the advantage of invulnerability to fouling or shorting and is protected from high chamber pressures. The unshielded element, on the other hand, offers faster response and higher ignition temperature source, and dissipates more wattage than the shielded-element glow plug.

- **Torch ignition systems**—These miniature rocket engines, so to speak, require propellants, valves, a combustion chamber, and an igniter. They are most often used in restarting operations of a large rocket engine or in heating the catalytic bed of a monopropellant engine. Many types of gas generators use this type of ignition to ignite and decompose the monopropellant fuel.

Such bi-propellant starter systems may use the main engine's fuel and oxidizer, or it may have its own supply. Some others use air for the main engine oxidizer and then utilize an injection of starter fuel and electrical ignition for starting.

A hypergolic-propellant torch starter can use either of the main engine propellants and a separate oxidizer or fuel that is hypergolic with one of the main engine propellants. Either or these may be used on monopropellant engines, since it takes additional heat to start the catalytic action or decompose the monopropellant. Spark and glow plugs have limited heat to decompose

VOUGHT BROADENS SPACE STUDIES

The *Scout*-type research rocket is a primary interest at Chance Vought, where this company's Astronautics Division is investigating the space-science as well as the military potential of such a vehicle.

Potential missions include boosting weather, commercial or military communications stations into space.

Astronautics Division concept studies of a passive electronics satellite and a reconnaissance satellite are producing additional valuable data in new and challenging areas.

Manned payloads for space are another major objective. Vought's work includes the man-carrying portion of the vehicle, and long-range studies aimed at training for space flight.

In specializing on crew quarters for space, this company draws on unequaled experience in human factors design for high-performance aircraft. As a member of the Boeing *Dyna-Soar* development team, Vought already has found this experience applicable to space.

Toward training for space flight, Vought has designed an orbital flight simulator. In a realistically furnished cockpit, using a new family of controls and instruments, the space trainee can "maneuver" into orbit and back to earth. More than 200 such "flights" have been made to date.

Space is the specialty of Chance Vought's Astronautics Division. Other major interests are being aggressively advanced in the Aeronautics Division — where attention is on atmospheric missiles, antisubmarine apparatus and piloted aircraft — and in the company's Electronics, Range Systems and Research Divisions.

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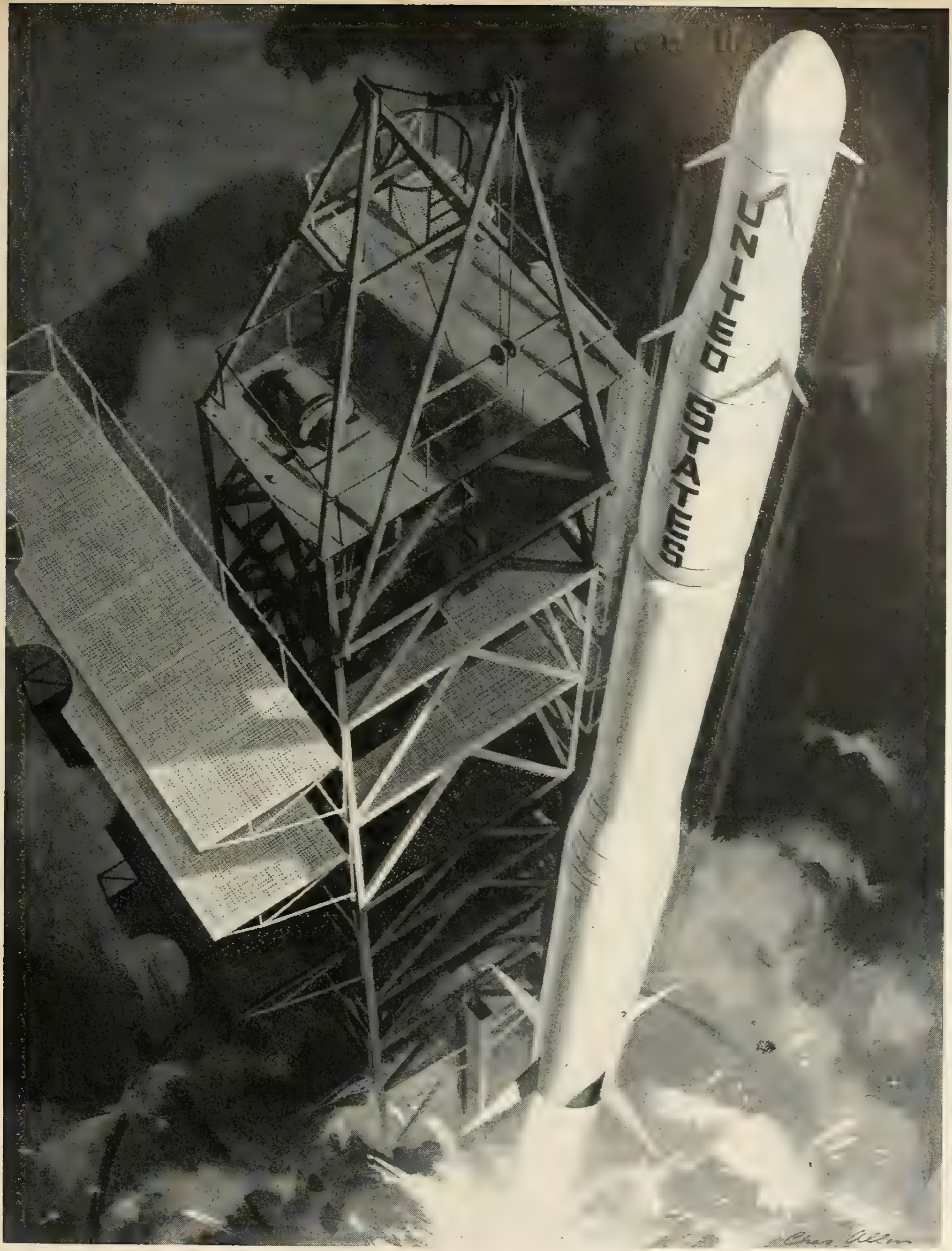

NASA'S SCOUT WILL MARK A TRAIL FOR MAN TO FOLLOW

Scout is designed to explore paths into space . . . at low cost. The inexpensive, 70-foot research rocket will go after vital space measurements that require sounding after sounding. National Aeronautics and Space Administration scientists will use the vehicle to launch the satellites and probes that measure the ionosphere, map magnetic fields and gauge radiation. Chance Vought's job is to assemble *Scout's* four stages, build its airframe and launching tower — holding to low cost and high reliability standards. *Scout* will make many of the hundreds of space soundings NASA already has scheduled. From this rocket's well-blazed trail, scientists may unlock secrets that will pave the way for extended manned space flights.

AERONAUTICS ASTRONAUTICS ELECTRONICS GENESYS CORP RANGE SYSTEMS RESEARCH

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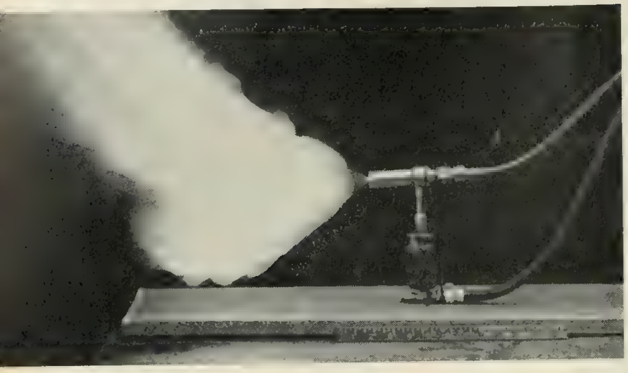


TORCH IGNITER by Aerojet-General uses gasoline, air and a spark plug. Units of this type are widely employed to restart big rocket engines.

such large volumes of monopropellants.

A given chamber pressure must be reached in the torch igniter before the propellant valves of the main engine can be opened for main engine operation.

- **Hot spot (heated wall) igniters**—Monopropellant rocket engines offer the greatest opportunities for applications of this method. The system is usually started by glow plugs, torch igniters, or preheated chambers. The propellant is usually metered into the chamber in small quantities until the hot spot or heated wall becomes an adequate heat sump to support continuous combustion.

In small engines, the glow plug is an adequate heat sump, but in larger engines, an additional heat source must be provided to insure continuous decomposition during starting transients. Stainless steel wire-mesh screens and cermet pellets or catalytic screens may be used in conjunction with stainless steel screens to insure decomposition of the monopropellant.

Typical monopropellants using this type of ignition are unsymmetrical dimethylhydrazine ($C_2H_8N_2$), N-propyl nitrate ($CH_3CH_3CH_2ONO_2$), ethylene oxide (CH_2CH_2O), and others.

- **Catalytic ignition systems**—A combination of catalytic beds and heated wire screens supporting the decomposition of a monopropellant characterize this method. When a 90% hydrogen peroxide (H_2O_2)/10% water (H_2O) propellant is used, the catalytic bed consists of silver-plated stainless steel wires.

Slow response time is a major objection to these ignition systems. This time may vary from 0.015 to 0.060 seconds and is considerably affected by motor size, propellant flow rate and chamber pressure. On small engines (compact, simple, efficient control engines) this type of ignition is excellent if the slow response time is tolerable.

- **Hypergolic ignition systems**—A very desirable, but limiting, method of rocket engine ignition utilizes hypergolic propellants. It limits the designer's choice of propellants, and requires strict handling procedures. Engines using hypergolic fuels must have precise start and shutdown procedures, to prevent occurrence of high starting and shutdown pressures in the combustion chamber and the injection system. These problems are also present in non-hypergolic systems, but not to such a great extent.

Ignition Systems for Missiles

Igniter System	Types	Methods of Initiation	Applications	Starting Use	Advantages	Disadvantages
Pyrotechnic	A. Black Powder B. "Alclo" Pellet C. "Alclo" Flare	A. Low Voltage Bridge Wire Squib B. High Voltage Explosive Wire Squib	A. Ignition of Solid Propellants 1. "Jato" assisted take off rockets 2. Solid rocket engines (Polaris, Minuteman, etc.) 3. Gas generators (solid) B. Bi-Propellant Liquid engines 1. Titan thrust chambers 2. Gas generators C. Monopropellant Liquid Engines 1. Rocket engines 2. Gas generators	Reliable Single Starts Non-Repetitive	A. High Reliability B. High Altitude Starts C. Fast Starts Without Shock Transient using "Alclo" Pellet type igniter D. Low Power Electrical Ignition System E. Large Area Coverage	A. Single Start B. Special Handling During Transportation and Installation C. Requires "Safe arm" Devices D. Limited Storage Life—5 years E. Temperature Sensitivity F. Short Duration
Electric	A. Spark Plugs 1. Air Gap 2. Semi-Conductor B. Glow Plugs 1. Open Element 2. Closed Element	A. Inductive 1. D.C. Supply 2. A.C. Supply B. Capacitive 1. D.C. Supply 2. A.C. Supply	A. Bi-Propellant Liquid Engines 1. Rocket Engines 2. Torch Igniters 3. Gas generators (APU) B. Mono-Propellant Liquid Engines 1. Air Turbo Rockets 2. Ramjets 3. Gas generators (APU) 4. Liquid Assisted Take Off Engines 5. Rocket Engines 6. Turbojets	Single and Repetitive Starts	A. Reliable Single Starts B. Longer Duration C. Safe Handling (non-explosive) D. Good Shelf Life E. Re-Usuable with Proper Maintenance F. Small Element G. Simple Electrical System using Glow Plugs	A. Can be Fouled or Shorted B. Indefinite Starting Time C. Heavy System (spark plug) D. Un-Reliable Restart E. Requires more Power than other Systems F. Sensitivity to Chamber Pressure (spark plugs) G. Sensitivity to Arc over of insulation, Shorts and High Altitude, and High Humidity Conditions H. Slow Response Time (glow plugs only) I. Some Systems Require Shielding for Radio Interference

Hypergolic-slug starting systems for engines, torch igniters, and catalytic-bed heaters are typical applications of this kind of system. Sequencing and metering of propellants are critical and require suitable care and control to insure smooth starting conditions.

Missiles using hypergolic ignition include *Corporal, Able,* some models of *Aerobee-Hi,* the *Bomarc* booster, some *Nike* boosters, and a number of liquid rocket sleds.

• **General trends**—In general, ignition systems for large rocket engines apparently will fall into two categories—single shot systems, which will mostly use pyrotechnic ignition; and restart systems, which will tend toward hypergolic ignition.

For smaller engines and control verniers, the trend will be toward pyrotechnic and glow-plug ignition for single-start systems, and toward hypergolic or catalytic ignition for restart systems.

Advanced starting systems being investigated for future use are: hypergolic ignition by use of hypergolic buttons or coatings, and chemical additives; electrical, by use of conductive films; and pyroforic fuels.

Each system has advantages and disadvantages; tailored to a particular propulsion system, each will do the job. Indications are that no one ignition system will ever be universal in its application.

Igniter System	Types	Methods of Initiation	Applications	Starting Use	Advantages	Disadvantages
Torch	A. Bi-Propellant with Electrical Ignition B. Hypergolic Slug	A. Ignition with Spark Plugs or Glow Plugs B. Acid Slug Introduced by Valving or Burst Diaphragm	A. "Boot-strap" Ignition of large Bi-Propellant Rocket Engines B. Ignition and Heating of Catalyst Beds and Heat Sinks of Monopropellant Engines 1. Gas generators 2. Rocket Engines 3. Air-Turbo Rockets 4. Liquid Assist. Rockets	Single and Repetitive Starts	A. Repetitive Starts B. Smooth Starts C. Large Heat Output D. Long Duration E. Large Area Coverage	A. Heavy System B. Requires Separate Fuel System and Electrical Components C. Reliability Reduced by Complexity of System D. Expensive
Hot Spot or Heated Wall	A. Glow Plug B. Heat Sink	A. Low Voltage AC or DC B. Torch Igniter	A. Mono-Propellant Rocket Engines* B. Auxiliary Power Units* C. Air Turbo-Rocket Gas Generators* *Using Mono-Propellants That do not Decompose by use of a Catalyst	Single and Repetitive Starts	A. Repetitive Starts B. Simple System (glow plugs) C. Fair Durations	A. Limited Application B. Requires Large Heat Sinks for Large Units—Heavy C. Slow Response D. Possibility of Fouling
Catalytic	A. Catalytic Bed B. Catalytic Bed + Heat Sump C. Catalytic Bed + Regenerator or Preheater	A. Pre-Heating B. Glow Plug C. Catalyst D. Torch E. Hypergolic Slug	A. Monopropellant Rocket Engines B. Auxiliary Power Units C. Attitude Control Rocket Jets	Single and Repetitive Starts	A. Repetitive Starts B. Simple System C. Fair Duration D. Good Control (Throttling)	A. Limited Application B. Shutdown Due to Contamination or Burn out of catalyst bed C. Slow Response D. Heavy Motor
Hypergolic	A. Hypergolic Propellants 1. Liquid 2. Solid + Liquid B. Hypergolic Slug 1. Oxidizer 2. Fuel	A. Propellant Valves B. Slug 1. Valved 2. Burst Diaphragms 3. Coating (solid)	A. Bi-Propellant Rocket Engines B. Hybrid Rocket Engines C. Mono-Propellant Engines D. Gas Generators	Single and Repetitive Starts	A Repetitive Starts B. Simple System C. Reliability Good D. Fast Response	A. Dangerous Propellants B. Requires Accurate Valve Sequencing to Obtain Smooth Starts and Shut Down C. Storage Problem on Many Propellants

Limits on Electrical Propulsion

PHILADELPHIA—The power supply weight problem will probably eliminate the electrical systems of propulsion for all but orbit-trimming or attitude-control maneuvers and, possibly, extremely high-energy flights to the outer planets.

The Institute of Radio Engineers last week heard Dr. Jerry Grey of Princeton say that at least two of the basic problems of the ion rocket, beam neutralization and accelerating electrode erosion, have not really been solved at the present time and that practical operation of any of the high-energy magneto-fluid mechanics devices has yet to be demonstrated. He said:

"These represent the only classes of high specific-impulse electrical devices; the other, the low specific-impulse electrical types such as arc plasma jet, colloid or dust rocket, etc., cannot compete weightwise with advanced nuclear heat-transfer rockets in the 1000 second regime."

Dr. Grey added that it was likely that these advanced nuclear rocket systems would reach operational status at least about the same time as an equivalent electrical system.

New Air Force Ranks?

WASHINGTON—Pentagon Air Force enthusiasts celebrated the turning over of all space transportation to the Air Force by drawing up a proposed list of new ranks befitting the Space Age.

Here is the list as amended by security wags:

Galacteer, Four Star; Liftenant Galacteer, Three Star; Majoris Galacteer, Two Star; Solardeer, One Star; Planeteer, Colonel.

Liftenant Planeteer, Lt. Col; Orbiteer, Major; Rangeer, Captain; 1st Liftenant, 1st Lt; 2nd Liftenant, 2nd Lt. Stageman, CWO; Jr. Stageman, WO; Senior Blasteer, CMS; Jr. Blasteer, SMS; Blasteer, M/Sgt.

Chief Nozzleman, T/Sgt; Jr. Nozzleman, S/Sgt; Padman 1st Class, A/c; Padman 2nd Class, A/2c; Padman 3rd Class, A/3c; and Basic Padman, Basic Airman.

There will be no restriction on a member of the Women's Space Force to keep her from reaching the rank of Galacteer provided she is prepared to go that far. (AF Regulations restricted women to the equivalent rank of Planeteer.)

Garlock's unique position in the missiles

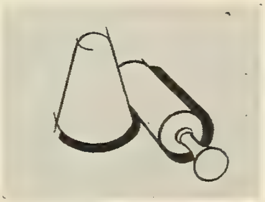
GARLOCK METAL FITTINGS FOR ROCKET MOTOR CASES such as blast tube and thrust terminator support rings are machined to extremely close tolerances. Made from special materials affording minimum weight, maximum strength and rigidity.

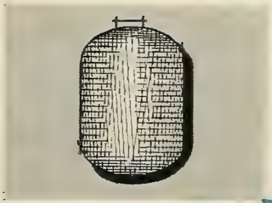
industry . . .

GARLOCK'S UNIQUE POSITION in the missles industry may be of infinite value to you.

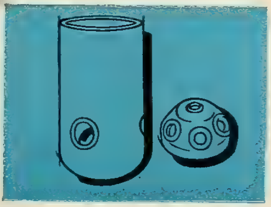
ACCEPTANCE: Right now Garlock is supplying rocket motor components for various phases of development and production of seven different missiles. **FLEXIBILITY:** Garlock has the people, the equipment, and the experience to swing into prototype production on short notice, and to follow this with full-scale production as needed. **DIVERSIFIED ABILITIES:** Garlock is thoroughly familiar with the design and manufacture of components from a wide range of basic materials—metals, rubber, phenolics, fluorocarbons and other plastics. **COMPLETELY INTEGRATED STAFF:** Garlock's product design, tool design, pilot manufacturing and production staffs are completely integrated for efficient handling of a project from start to finish. Garlock engineers will work to your design—or with you in developing designs. Write or call Military Products, The Garlock Packing Company, Palmyra, New York. GARLOCK

MISSILE PARTS FROM INERT MATERIALS include newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.





FILAMENT WOUND ROCKET MOTOR CASES made by exclusive Garlock method results in structure much lighter and stronger than steel.



INSULATION FOR SOLID FUEL ROCKET MOTORS made by Garlock is rubber-like compound which encounters gas velocities of Mach 3, temperatures to 5500°F, prolonged ambient temperatures of 300°F.

Garlock components are presently used in the development and production of:

Vanguard	Minuteman	Super Tartar	Polaris
Super Vanguard	Nike Hercules	Terrier	

Ion Rockets Lead in 'Exotic' Propulsion

BOSTON—The progress of ion and plasma research in space flight applications was the subject of the only open session at the Second Symposium on Advanced Propulsion Concepts, jointly sponsored by **Avco**-Everett Research Laboratory and the Air Force Office of Scientific Research.

The ion rocket emerged as most likely to reach flight test capabilities first, based on current state-of-the-art development.

T. M. Littman of **Rocketdyne** said that although the feasibility of obtaining thrust from ionic, plasma jet and magnetohydrodynamic devices has been demonstrated, none of the systems has been proven practical from an engineering standpoint.

The Symposium featured a panel discussion moderated by Dr. Arthur Kantrowitz, Director of the Avco-Everett laboratory and member of the M/R Advisory Board. The panel included Brig. Gen. B. G. Holzman, Commander of the Air Force Office of Scientific Research; Brig. Gen. H. A. Boushey, Director of Advance Technology, USAF; Col. Robert W. Christy, Commander, 644th Missile Squadron, Vandenberg Air Force Base; Dr. Horace N. Gilbert, economist, California Institute of Technology; Dr. Thomas Smith, historian, University of Oklahoma, and Clarke Newlon, Executive Editor of MISSILES AND ROCKETS.

The abstracts of papers given in the session on Ion and Plasma Research are presented as a service to M/R readers. Further information may be obtained by contacting either the authors or the editorial office of MISSILES AND ROCKETS.

Magnetohydrodynamic Acceleration of Slightly Ionized, Viscously Contained Gases, G. Sargent Janes and James A. Fay, Avco-Everett Research Laboratory, Everett, Mass.

The various physical and aerodynamical factors affecting the design of a steady flow MHD accelerator having viscous containment and crossed electric and magnetic fields are considered for the case of a slightly ionized gas. These include the effects of tensor electrical conductivity, ion slip, current diffusion, frozen flow and leaving losses, magnetic field and electrode losses, and viscous boundary layer losses. Some of the effects are also applicable to the case of a completely ionized gas. This may be the more interesting case, but it is not considered in detail. A particular example portraying most of these effects is presented for the case of a slightly ionized gas.

The Colloid Rocket: Progress Toward a Charged-Liquid-Colloid Propulsion System, Robert D. Schultz and Lane K. Branson, Aerojet-General Corporation, Sacramento, Calif.

Theoretical and experimental research is described leading toward a space propulsion system in which microscopic oil droplets are produced with a high positive charge and accelerated electrostatically to exhaust velocities of over 50,000 mph with I_{sp} of over 2200 seconds. This type of rocket system may prove to be of considerable value for controlling the orbit of an earth satellite, for earth-moon missions and possibly for deep space exploration such as a Mars or Venus probe.

A Detonation Wave Hypersonic Ramjet, W. H. Sargent and R. A. Gross, Fairchild Engine Division, Deer Park, N.Y.

This report examines the performance of a hypersonic ramjet having a detonation wave combustion process. Flight speeds from Mach 2.5 to Mach 10 are investigated. Engine performance characteristics are presented and compared with those of a conventional ramjet.

Pulsed Plasma Accelerator, Thomas L. Thurson, Research Center, Borg-Warner Corporation, Des Plaines, Ill.

The various types of pulsed plasma accelerators using a Lorentz force for acceleration are examined. The Bostick source, the rail type gun, the Avco coaxial shock tube, and the Kolb shock tube are presented and the experimental difficulties of each are discussed. The simplicity and fair reliability of pulsed plasma accelerators are the main advantages of the system for use in space propulsion.

A Critical Evalution of the Ion Rocket, T. M. Littman, Rocketdyne, Canoga Park, Calif.

A critical evaluation of the current status and future potentialities of the ion rocket is presented. Comparison is made, insofar as possible, with both conventional rockets and other electrical propulsion schemes. It is concluded that the ion rocket is unique among the advanced systems in its relative simplicity, high efficiency, wide range of applicability and early availability of a low-power flight model.

The Production and Study of High Speed Shock Waves in a Magnetic Annular Shock Tube, Richard M. Patrick, Avco-Everett Research Laboratory, Everett Mass.

A magnetic annular shock tube has been used to produce magnetically driven shock waves with very high velocities. Experiments were carried out with this device with two magnetic field configurations ahead of the shock front in the direction of motion of the shock. In the second configuration the magnetic field ahead of the shock had its principal component in the plane of the shock front and a small component in the direction of motion of shock. The continuum radiation emitted by the shock-heated plasma was measured with photo-multipliers. The use of probes to measure the change in the local magnetic field in the shock front was investigated. With the second configuration, shock velocities in excess of 4 x 107 cm/sec were measured in hydrogen. For these high speed shock waves, a shock thickness was obtained from measured rise times of the emitted visible radiation. These shock thicknesses are thinner than the mean free path in the shock-heated plasma, an observation which agrees with a theoretical prediction.

The Arc Jet, Dr. Gabriel M. Giannini, Avco-Everett Research Laboratory, Everett, Mass.

Space flight propulsion studies definitely indicate that for practically all space missions electrically driven rockets offer a substantial saving in mass over chemical rockets. If these studies are limited to satellites and moon missions, they show that the most advantageous I_{sp} is in the 2000 to 3000 second range. Thus, the arc jet becomes suitable for this type of application. The paper presents the results of typical mission studies and outlines the analytical and experimental work conducted to develop the plasma jet as a means of propulsion. The results of various phases of the program are presented and discussed in the order they were obtained. On the basis of these results a plasma-propelled space ship appears feasible.

Cesium Ion Motor Research, R. C. Speiser and G. R. Dulgeroff, Rocketdyne, Canoga Park, Calif.

Experimental studies with cesium surface ionization devices operated as miniature ion motor configuration are discussed. Such studies cover many of the phenomena of significance to the development of practical sized ion motors even though conducted on a small scale. The results indicate that the system can provide adequate current densities for electrostatic ion propulsion at moderate temperatures, and no major technological "break-through" is necessary for the development of a practical cesium surface ionization motor.

Charged Droplet Experiments, Charles D. Hendricks, Jr., Ramo-Wooldridge Consultant, University of Illinois.

The paper describes the experimental techniques by which charge-to-mass ratios and drop size of the individual droplets were measured. Broad distribution were found for radii and charge-to-mass ratio. The charged oil droplets were obtained through use of a small hollow needle raised to a high potential.

Titanium, Plastic Rocket Cases Gain

But steel holds near-monopoly in choice of material for solid cases because of its low cost and wealth of experience in handling

by Jay Holmes

WASHINGTON—Titanium, laminated plastic and aluminum are challenging steel's near-monopoly in the supply of materials for solid rocket motor cases.

Steel still holds the edge, primarily because of its low cost and the wealth of knowledge about its properties. But the day may come when booster and second stages will be made of these newer materials.

What are the demands placed on a material for rocket cases? First, of course, it must be strong. Second, it must be light. Third, it must be at least relatively inexpensive; we may be willing to pay a little more for greater performance, but there is a limit to every budget.

There is a fourth requirement that isn't as easy to express in numbers. That is reliability—we want a rocket case we can depend on.

Steel is the strongest material available. But it is also one of the heaviest. Its density ranges from .27 to .28 lbs./cu. in. This compares with .16 for titanium, .098 for aluminum, and as low as .072 for filament-wound glass fiber bonded with resins.

The best measure of these two factors together is the strength-to-weight ratio. Strength is measured in pounds per square inch strain that can be withstood without rupture—the ultimate tensile strength. Density is measured in pounds per cubic inch. Thus the ratio comes out in inches.

Take, for example, a steel with tensile strength of 240,000 psi. If its density is .27 lbs./cu. in., the strength-to-weight ratio would be 890,000 inches.

FIRST TITANIUM used on a large scale for missiles was this 50-pound helium bottle in Convair *Atlas*. Aluminum bottle would have weighed 80 lbs., steel 125.

• **Toward "magic million"**—The rocket maker's aim in the last few years has been to better this ratio—to get it up to the so-called "magic million." Much progress has been made in steels: better alloys have been developed; better heat-treating processes have been developed, such as that announced last month by **Research Development Corp. of America** (M/R, Sept. 28, page 10); welding has been improved to the stage where when rocket cases burst in tests of their ultimate strength, the burst no longer occurs at the welding seams.

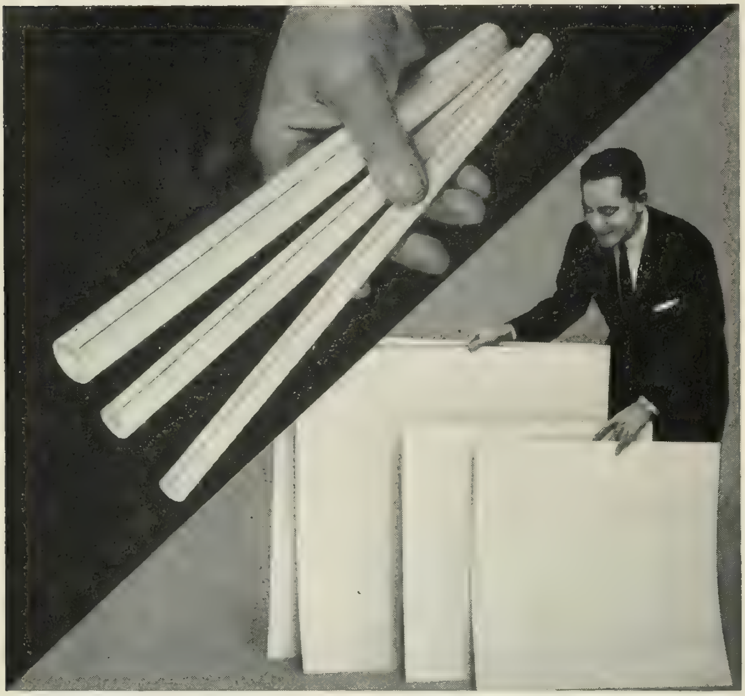
Furthermore, such processes as the strip-winding technique developed by **Ryan Aeronautical Co.** have raised the ratio still higher. Ryan says it can get ultimate stress up to the neighborhood of 300,000 psi with this method.

But titanium and plastics may be able to do as well in a single leap. **Titanium Metals Corp. of America** reports it has developed an alloy with 190,000 psi ultimate yield strength. This would put the strength-to-weight ratio in the area of 1,200,000 inches. A simple aging process, TMCA says, can increase the strength to 200,000 psi for a ratio of 1,250,000.

With the glass fiber-resin combination, the figures are even more amazing. **Hercules Powder Co.** says its Young Development Division has developed a material with ultimate

TEFLON* NEWS FROM R/M

Now, larger sheets... color-striped thin-wall tubing



Easy identification in multiple tubing installations is made possible by R/M color-striped thin-wall "Teflon" tubing. Tubing is also available without striping.

Larger sheets. R/M now makes 1/32-in.-thick Teflon in 36 x 36 in. sheets. Other "Teflon" products include tape, tubes, rods, hose and bondable "Teflon."

Here are two big features added to Raybestos-Manhattan's extensive line of "Teflon" products for use in aircraft, missile and rocket components. First, 1/32-in.-thick "Teflon" can now be supplied in 36 x 36 in. sheets . . . other thicknesses available in sheets up to 48 x 48 in. And second, to permit the ready identification of lines in multiple installations—R/M thin-wall "Teflon" tubing is now available with a permanent identifying stripe in a range of colors.

These additions reflect R/M's continuing program to extend applications for "Teflon." This program — begun soon after the introduction of "Teflon"—has provided R/M engineers with a vast fund of know-how . . . where to apply "Teflon," how to design with it, and how to fabricate it. Let R/M's "Teflon" know-how work for you. Contact your nearest R/M district office for friendly, competent assistance. Or write for literature to Plastic Products Division, Manheim, Pa.

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Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

strength of 135,000 psi and density of .072 lbs./cu. in. This gives it a strength-to-weight ratio of more than 1,800,000.

Aluminum is in there pitching, too. Although its figures don't show up as well as plastic and titanium, **Alcoa** reports an alloy with strength-to-weight ratio of about 830,000—which compares favorably with steel.

• **Solid battleground**—The scene of battle is the lower stages of the big new solid-fueled missiles: the Air Force **Boeing** *Minuteman*, the Navy **Lockheed** *Polaris*, and the Army **Martin** *Pershing*. The decisions are made by case fabricators, propulsion contractors, primes and the services themselves. Design engineers propose choice of material—but cost accountants dispose.

Laminated plastics made the first inroads in steel's domination. Hercules produced a small, high-performance rocket that was used as the final stage of last year's Air Force *Pioneer* moon shots. The rocket was adapted as the third stage of last month's successful *Vanguard III*. Hercules now proposes to use a similar bird, scaled up somewhat, as the third stage of *Minuteman*.

Titanium is being tested for the lower stages—the second stage of *Polaris* and both stages of *Pershing*. Wright Aeronautical Division of **Curtiss-Wright** is making two prototype titanium *Polaris* cases for **Aerojet-General. Pratt & Whitney** is making the *Pershing* cases for **Martin-Orlando.**

Early this year, a titanium fourth stage carried *Pioneer IV* into an orbit around the sun—the first object to be pushed by American rocketry out of the earth's gravitational field. The switch from steel to titanium made it possible to add two pounds—about 20%—to the payload.

• **The money bind**—But the question of cost has raised its ugly head in the *Pershing* program. The Army has a budget even tighter than those of the other services. Mill titanium costs something like $7 a pound, compared with about $1.50 for vacuum-melted steel. For this reason, the Army has tentatively decided to scrap the *Pershing* titanium program. The decision will not be final for a few weeks, but with the current bind on Army money it is hard to see how it can be reversed.

Another factor in Army thinking on *Pershing* is the theoretical 200-mile range limit on Army weapons. Even with a steel case, *Pershing's* range approaches 700 miles. You don't have to be privy to military secrets to be able to figure that the range would be substantially extended by a switch to titanium.

• **Other uses**—Elsewhere in missiles, titanium already is making struc-

THOR
MACE
TITAN
HAWK
ATLAS
NIKE B
BOMARC
NIKE ZEUS
SPARROW I
SPARROW II
SPARROW III
NIKE HERCULES
SIDEWINDER
REGULUS II
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BULL PUP
POLARIS
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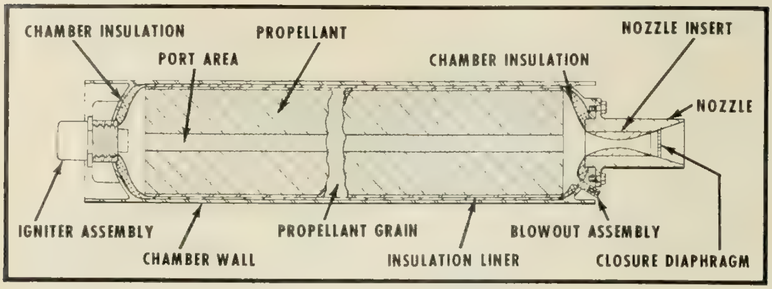


THE BATTLEGROUND: A typical solid rocket propulsion unit.

tural inroads. The first use of the metal on a large scale was in the liquid-fueled **Convair** *Atlas*. Spherical helium bottles, ranging in diameter from 16 to 24 inches, were made of titanium after original studies showed one type of bottle could be produced at 50 pounds. Weights for other metals were aluminum, 80 pounds, and steel, 125, TMCA reported.

The alloy chosen for the *Atlas* job was so-called "6-4"—titanium plus 6% aluminum and 4% vanadium. This is an alpha-beta combination: Alpha titanium has a close-packed hexagonal atomic structure; Beta titanium has a body-centered cubic lattice, that is, the atoms are stacked in array corresponding to the corners of regularly stacked cubes, with an additional atom at the center of each cube.

Recently, TMCA introduced an all-beta titanium alloy, with 13½% vanadium, 11% chromium and 3% aluminum. The alloying ingredients increased the density to 0.17 lbs./cu. in.

Beta titanium gains considerably in strength by simple aging at temperatures between 800 and 900°F. It need not be quenched, as in normal heat-treat processes. TMCA spokesmen say this provides a manufacturing economy that partly offsets the raw material cost.

• **Participation**—TMCA, jointly owned by **National Lead** and **Allegheny Ludlum,** is the largest producer of mill titanium and the only integrated producer of both raw titanium sponge and mill products. Other titanium mill producers are **Mallory-Sharon, Crucible Steel,** and **Republic Steel.** Other sponge producers are **Union Carbide Metals Corp., du Pont, Dow Chemical,** and **National Distillers.**

Compiling a list of the firms interested in laminated plastic glass fiber for rocket cases would be a herculean task. Some of those in the field are **Lamtex, Thompson Fiber Glass, Continental Diamond Fibre, Haveg Industries,** and **Zenith Plastics,** a subsidiary of **Minnesota Mining and Manufacturing,** in addition to Hercules.

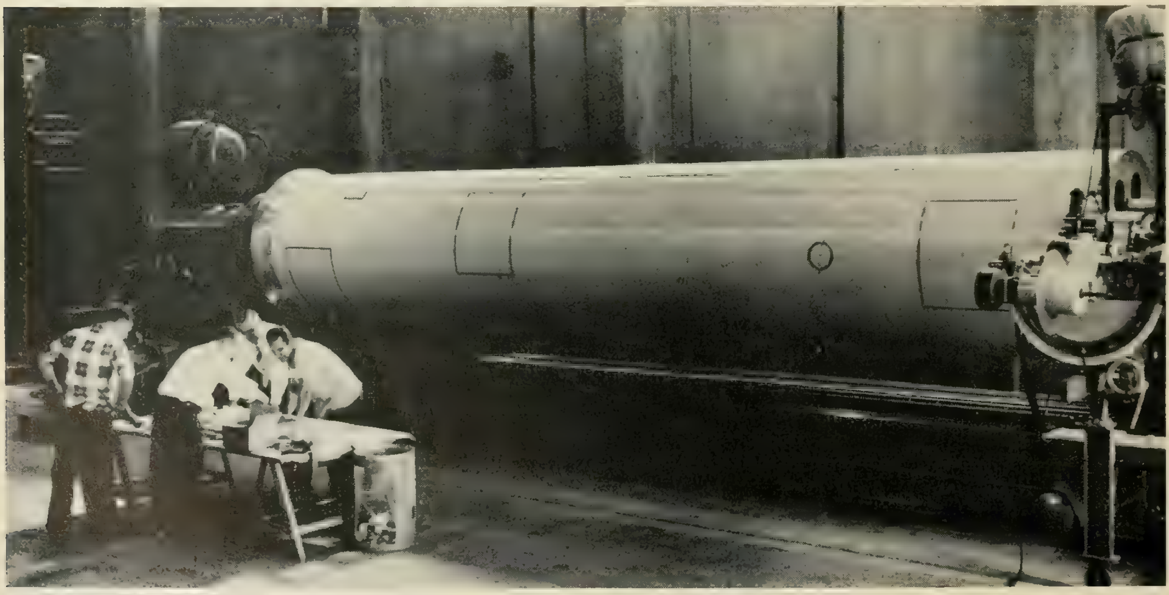
Recently, Zenith delivered a plastic cylinder 25′ long and 57″ in diameter to Lockheed. Zenith said it was the largest reinforced plastic cylinder ever made. The cylinder, a shipping container liner, weighed less than 1000 pounds and replaced a metal cylinder. Zenith said the production of the cylinder demonstrated that large missile cases also can be made of such material.

Lamtex says it has made plastic cases for *Nike-Hercules, Bomarc, Little John, Pershing* and *Minuteman* at one-half the weight of similar structures in steel.

Filament-wound motor cases consist of about 80% glass fiber and the rest plastic—usually epoxy resin. The fiber is wound at high tension around a mandrel while the resin is applied in a pasty condition. Two winding systems almost at right angles to one another prevent the fiber from separating laterally.

Hercules winds one filament in a system nearly parallel with the cylinder axis. The other is circular. The near-axial filaments can be passed over an end shape to provide closure.

• **What about heat?**—A question often raised about both titanium and plastic cases is their resistance to high temperature. Actually, this is less important today than formerly. Modern



HUGE PLASTIC CYLINDER was recently delivered to Lockheed by Zenith Plastics for use as shipping container liner. Zenith said the fabrication proved the possibility of making big plastic rocket cases.

solid fuel grains are excellent thermal insulators. Since they burn from the center out, the case itself is not heated until the last instant. If it fails at that moment, the failure doesn't matter, since the rocket already has provided its full quota of propulsion. However, the case itself provides additional insulation. It is actually possible to touch a small plastic rocket a moment after firing without burning your hand.

Both titanium and plastic claim an advantage over steel in their corrosion resistance—a factor particularly important for weapons such as *Polaris* and *Minuteman,* which must be stored for long periods of time in places where they might to subject to rusting or attacks by salt water.

The biggest objection to plastic has been its tendency to absorb water from the atmosphere when stored over a long period. This might tend to weaken the structure.

Titanium's major headache has been notch sensitivity—the tendency of a high-strength, heat-treated metals object to weaken in spots where a notch or indentation has been cut into it. Steel has notch-sensitivity problems too, but some steelmen say the problem is even greater with titanium. Titanium spokesmen vigorously deny this.

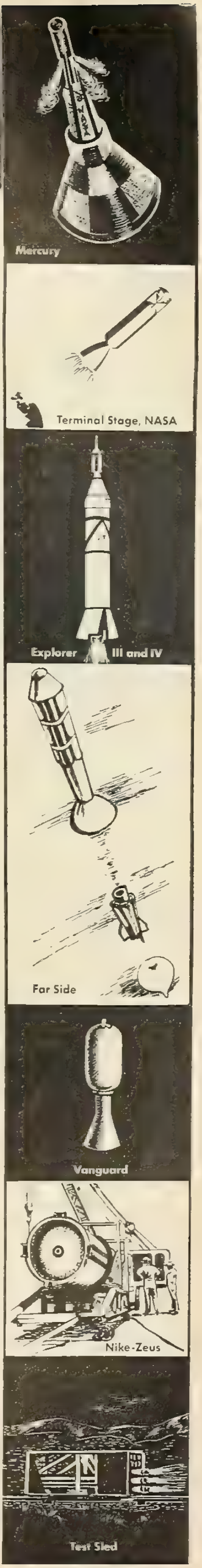
However, the greatest barrier to the immediate use of these newer materials for rocket cases is the concept of "historical reliability." So much more is known about steel and its properties that users can predict with greater confidence what it will do under every sort of condition.

Furthermore, the Air Force and Navy feel that the nation's survival may depend on development of some kind of *Minuteman* and some sort of *Polaris* as soon as humanly possible. And so orders have gone out to develop these two weapons with a bare minimum of new concepts. Such refinements as titanium or plastic rocket cases will have to wait until later.

Gauge Is Sensitive to One-millionth of an Inch

SEATTLE—A unique "Mag-Ray" gauge—developed at **Boeing's Aero-Space Division**—is so sensitive that it can indicate difference of one-millionth of an inch. One portion of the dual instrument measures capacitance changes, the other the intensity of beta-ray reflection.

The gauge was developed for such measurements as plating thicknesses on *Bomarc* missile timer discs—where both nickel and rhodium platings must be measured. Future applications include measurement of ceramic coatings, paint, and other thin films.



THE GRAND CENTRAL REPORT

In the short history of United States rocketry, solid propellant powered upper stage vehicles have established the U.S. altitude record, injected our first satellites into orbit, and have pioneered our first penetration into translunar space.

Why are solid propellants being used for these important space applications? The answer to this question is the ever increasing importance of reliability, time, and money to the competent and dedicated men who are managing our space programs.

A solid propellant rocket is inherently reliable because it is intrinsically simple. *For example, the GCR solid escape rocket for Project MERCURY will have a reliability factor of better than .99 at a confidence level of 95%.* Such a high reliability factor will really "pay off" for the giant sized multi-stage and clustered motor vehicles now being considered because the overall propulsion reliability is the product of the individual motor reliabilities.

Also, because of their basic simplicity, solid rockets can be developed in a very short time. For example, the third stage motors for the successful VANGUARD satellite vehicles were developed by Grand Central Rocket Co. in the brief space of nine months.

Finally, because of their simplicity, reliability, and short development time, solid rockets have proved to be the least expensive form of rocket propulsion.

Here, then, in the field of low-cost instrumented space probes, is an area where solid propellant rockets are in the ascendancy. I believe the next few years should see the development of very large solid propellant rockets. These may be used for launching tremendous payloads into orbit, and from there, man will eventually penetrate into the far reaches of interplanetary space. We will use low thrust nuclear powered rockets for interplanetary transfer, but I believe we will take reliable high thrust solid rockets with us for the descent maneuvers to the new worlds, and for safe return to our Earth.

These events will trace Man's first struggling steps into deep space and forever welcome him to his ultimate environment, the Universe.

H. L. Thackwell Jr.

H. L. Thackwell, Jr.,
Vice-President Advanced Concepts

(If you have the qualifications that a fast-moving space propulsion team needs, contact our Director, Personnel. Openings now for chemists and engineers.)

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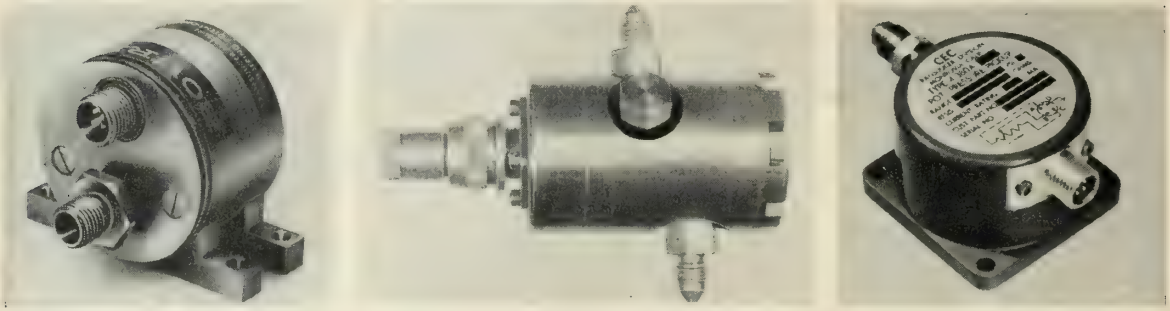
And Food Machinery and Chemical Corporation
P. O. Box 111 Telephone: PYramid 3-2211
REDLANDS, CALIFORNIA

Healthy Transducer Market Promises Even Greater Future Potential

M/R survey shows that the industry is dominated by fewer than 10% of the manufacturers



TRANSDUCER DEVELOPMENTS are reflected in these products. Left: Bourns Laboratories employs an unusual Bourdon tube movement for operation to 35G at 200 cps vibration. Crescent Engineering transducer, center, has a sensitivity of 100 millivolt 1 volt full-scale. CEC model has withstood 100 G shock.

by Charles D. LaFond

WASHINGTON—Only a handful of companies carry the lion's share of the annual $90-million transducer market today. But—just like the better mousetrap—the field has an even greater money potential for manufacturers who come up with solutions in vital problem areas.

The role of transducers in missilery and astronautics principally involves support equipment. Upon transducers falls the task of providing the means for faithfully reproducing a multitude of variable quantities that must be measured.

To do this, each transducer—regardless of function—must impose a negligible load on the variable under measurement. And—above all—the response must be free of all other variables being experienced by the tested system.

As in many other fields of the missile industry, these criteria have created new needs: better environmental testing, new materials to withstand high-g acceleration and shock, high temperature, vibration and corrosive atmospheres.

Production techniques are dictated by the required product quality and costs are restricted by competition. M/R has located over 130 companies in this country alone actively producing from one to seven basic types of transducers. But, who are the leaders in the field and what is being accomplished?

As already indicated, a few manufacturers are dominating multi-million-dollar business. But other companies now nibbling at the outer edge could at any time secure a larger piece with a significant breakthrough in any one of the problem areas.

Statham Instruments, Inc., reports that it is carrying about 10% of the whole transducer business. Principal products are pressure transducers, accelerometers, and load cells of the unbonded strain gage type. Significantly, a company spokesman says missiles are accounting for a much larger share of the total market than aircraft flight test applications and wind tunnel investigations combined.

Transducer Breakthroughs Needed Now

To help manufacturers build the proverbial "better mousetrap," this M/R survey has revealed some of the products needed tomorrow:

- *For use with associated missile servos, a feedback potentiometer for operation in 1000°F temperature environment.*
- *A 2-to-5-volt high output strain gage for direct coupling to telemetering subcarrier without amplification.*
- *A digital output transducer for test use.*
- *Vastly improved magnet wire, lead wire, and potting compounds to withstand all the severe environments and rapid environmental changes experienced by tomorrow's missiles and spacecraft.*

Baldwin-Lima-Hamilton Corporation's Electronics and Instrumentation Div. until two years ago held the patent for bonded strain gage transducers. Although they licensed a few outside corporations to produce them for limitated applications, BLH controlled the whole market.

The company estimates the total missile market for load cells and pressure cells at $2 million and $10 million, respectively. Seventy-five per cent of the load cell business is theirs, although they have only about 5% of the pressure cell market.

The Garrett Corporation's AiResearch Manufacturing Co. has been developing and producing transducers for over 10 years. Their principal field has been the external environments for flight testing missiles, drones, and aircraft.

They have also exerted great effort in developing devices for use in controlled flight regimes for space vehicles during atmospheric exit or re-entry.

In 1950, the company produced

what it feels was the first ". . . true, servoed, force-balance transducer for Mach number and altitude." Since then, AiResearch believes, it has led the field in the production of this type transducer. In one application alone, engine pressure ratio indicators, more than 10,000 systems have been built, said a company spokesman.

AiResearch also stated that it built the first force-balance, multiple output Mach and altitude transducers. More than 10,000 of these are now employed in aircraft and winged missiles.

Another manufacturer prominent in the air data transducing field is **Minneapolis-Honeywell Regulator.** The company carries a complete line of units ranging from very accurate force-rebalance transducers to low-cost, lightweight, direct-driven air data devices.

Principal manufacturer of piezoelectric accelerometers is believed to be **Gulton Industries, Inc.** In addition, the company stated that it carries a very complete and diversified line of transducers for industry and the military.

Crescent Engineering and Research Co. is a leader in the production of AC electro-mechanical transducers—linear differential and variable permeance and reluctance types.

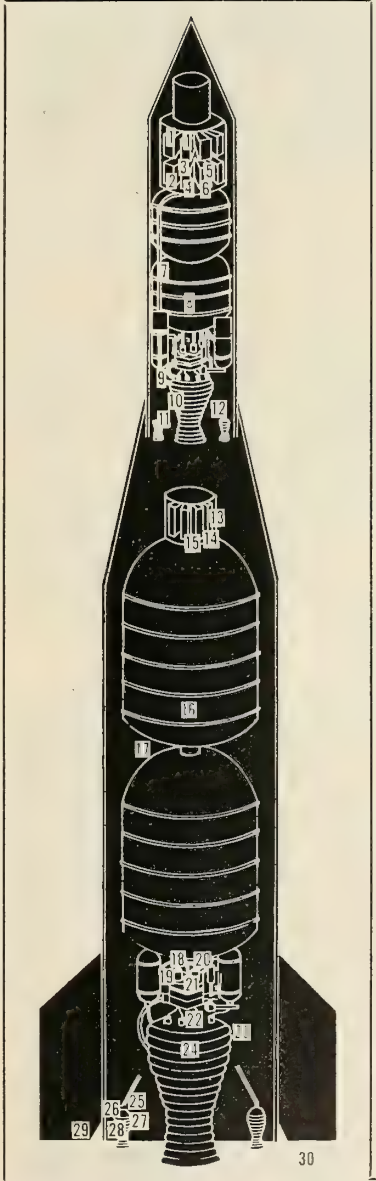
Consolidated Electrodynamics Corporation's Transducer Division has made inroads on the chamber-type unbonded strain gage pressure transducer market. The company has applied its effort toward developing units covering broad pressure ranges (100-10,000 psi) wide high temperature operation (–320° to 2000°F), and high-g shock (100 g) and acceleration.

It is not possible to list all of the other 130-odd transducer manufacturers, but here is a summary of some of the important producers.

- **G. M. Giannini & Co., Inc.**—accelerometers, low- and high-pressure transducers, probe and vane types for temperature, pressure, pitch and yaw.
- **Bourns Laboratories, Inc.**—position and pressure transducers.
- **Colvin Laboratories, Inc.**—low to medium pressure devices.
- **Standard Controls, Inc.**—bridge, unbonded, pressure transducers.
- **Taber Instrument Corp.**—bridge, bonded, pressure transducers, an extensive line for liquid and gas.
- **Vinson Manufacturing and Sales Co.**—all types of motion transducers.
- **Kearfott Co., Inc.**—accelerometers and temperature sensors.
- **Arnoux Corp.**—temperatures sensors.
- **Wallace O. Leonard, Inc.**—accelerometers, flow and pressure transducers.

Types of Transducers

Von Nostrand's Scientific Encyclopedia, Third Edition, defines a transducer in its more narrow sense as a ". . . device capable of being activated by waves from one or more transmission systems or media, and of supplying related waves to one or more other transmission systems or media."



PREPARED BY Crescent Engineering and Research Co., this typical missile configuration indicates the variety of transducer applications in a single vehicle.

(1) Autopilot system, (2) propellant ratio control system, (3) translator, (4) rotary transducer (pickoff balance transducer), (5) HC-250-4E linear transducer (programmer), (6) HC-265-4E linear transducer, (7) tank differential pressure transducer and indicator system, (8) pressure transducer (propellant motion), (9) velocity transducer (actuator feedback damping), (10) linear transducer (sustainer autopilot feedback), (11) rotary transducer (vernier actuator telemetering pickoff), (12) rotary transducer (vernier gimbal autopilot feedback), (13) linear transducer (programmer), (14) linear transducer (programmer), (15) linear transducer (programmer, (16) pressure transducer (propellant motion), (17) tank differential pressure transducer, (18) pressure transducer (propellant ratio), (19) pressure transducer, (20) rotary transducer (propellant valve pickoff), (21) rotary transducer (valve position pickoff), (22) rotary transducer (booster gimbal pickoff, ground monitoring), (23) booster actuator linear transducers, (24) pressure transducer (autopilot actuator feedback damping), (25) rotary transducer (gimbal autopilot feedback), (26) linear transducer (vernier ground monitoring instrumentation), (27) linear transducer (vernier actuator servo pickoff), (28) linear transducer (vernier actuator servo pickoff), (29) rotary transducer (control surface pickoff), (30a) ground installation test transducers (linear transducer position pickoffs-tank, engine, etc., ground test), (30b) linear transducer (signal comparator ground test).

Briefly, there are three general classifications for transducers based on their electrical pickup configurations: inductance, resistance, and output voltage. All are variable.

The resistance types employ either bridge or potentiometer circuitry. The output voltage types use the piezoelectric effect (generation of an electrostatic voltage by crystal compression).

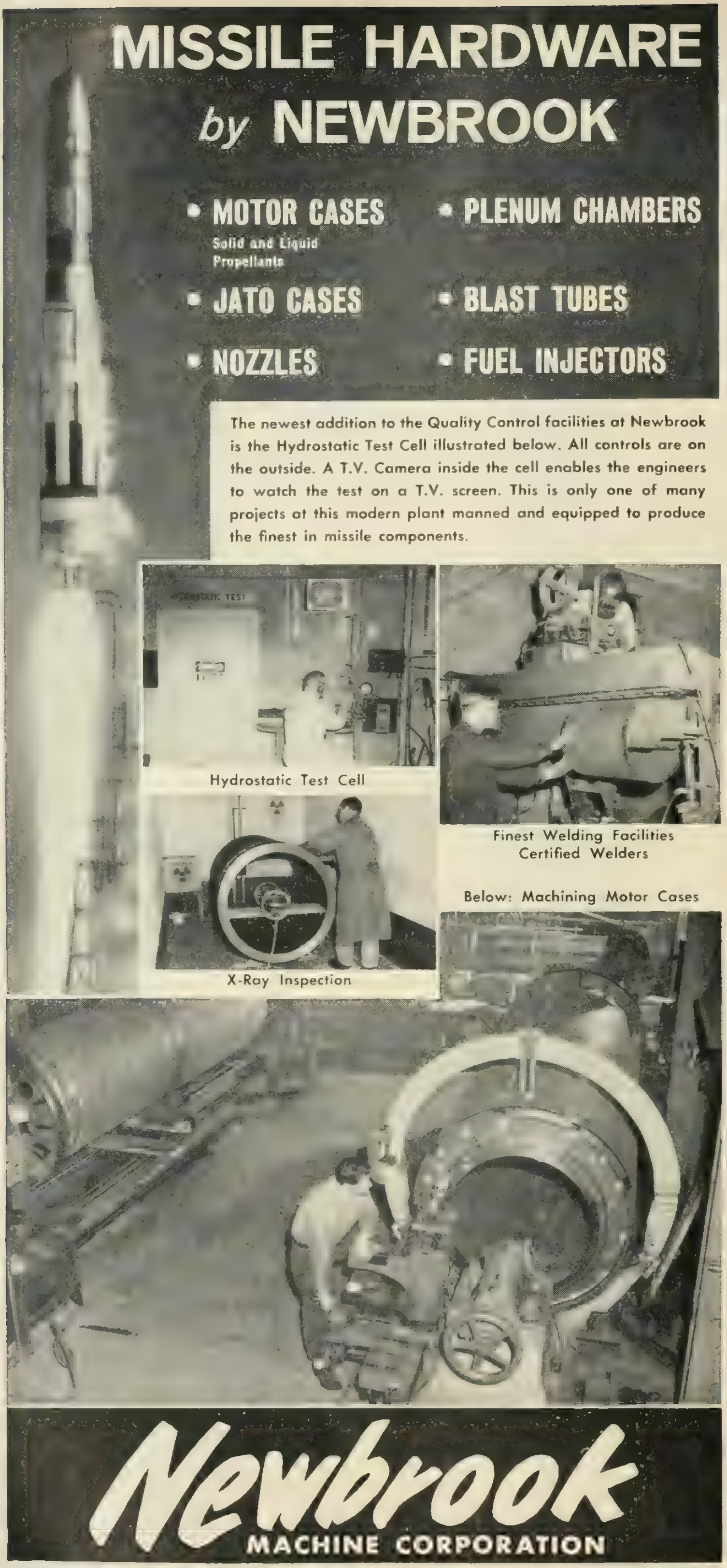
In missile-telemetry applications, principal functional types of transducers are used to measure the following: acceleration, position or motion, force, pressure, strain, temperature and vibration.

- Acceleration—Accelerometers use either a change of inductance or resistance to translate linear or angular accelerations into usable measurement data. The response is seismic in producing a proportional voltage output.
- Position or motion—Transducers are available for indicating an angular position or angular or linear motion. Either a variable inductance or potentiometer type can be used. The former employ a rotating shaft to alter inductance and is used to register small torque or short linear distances. The latter finds greater application for high-frequency motion—either angular or linear.
- Pressure—Changes in fluid pressure are translated by differential pickups employing changes in inductance or resistance. From here on it is difficult to generalize with brevity for there are different ranges requiring different pressure-indicating techniques.

For low, medium, and broad-range transducers, a two-chamber, diaphragm type is used with an "E-coil" inductor rigidly mounted and serving as one wall in one chamber.

Inductance in the E-coil is changed with pressure differentials between the two chambers by means of a high-permeability material in a pad secured to the diaphragm.

Transducers of this type handle pressures ranging from 0.4 psi to 3000 psi. They are limited by case construction and the application of unequal



MISSILE HARDWARE
by NEWBROOK

- MOTOR CASES
  Solid and Liquid Propellants
- PLENUM CHAMBERS
- JATO CASES
- BLAST TUBES
- NOZZLES
- FUEL INJECTORS

The newest addition to the Quality Control facilities at Newbrook is the Hydrostatic Test Cell illustrated below. All controls are on the outside. A T.V. Camera inside the cell enables the engineers to watch the test on a T.V. screen. This is only one of many projects at this modern plant manned and equipped to produce the finest in missile components.

Hydrostatic Test Cell

Finest Welding Facilities
Certified Welders

Below: Machining Motor Cases

X-Ray Inspection

Newbrook
MACHINE CORPORATION

45 MECHANIC ST. Phone: Yellowstone 4-2644 SILVER CREEK, N. Y.

pressures to the two chambers. Mechanical detents may be employed, but only on one side, as a protection against sudden overload.

For altitude, a modified unit is employed. It uses an aneroid cell instead of the diaphragm with magnetic pad (mu-metal) attached. Operation is otherwise similar.

For a somewhat limited range from 600 to 3000 psi, a bourdon tube and an E-coil inductor are used. The magnetic pad is secured to the tube, and the whole is encased. Pressure applied to the open end of the tube causes it to bend with a resultant change in coil inductance. A correction factor is necessary with any change in altitude, although the error is slight (less than 1%).

• Force—Mechanical force transducers, dynamometers, are varied and have broad application. A typical type consists of an E-coil mounted in one elastic ring and a mu-metal pad secured to another ring diametrically opposite the E-coil. With this arrangement, both tension and compression can effect a power translation by changing coil inductance.

• Vibration—Because of the frequencies involved, transducers using the piezo-electric effect are common for vibration pickup. They vary greatly in shape, size, and capability. Outputs of the order of 8 millivolts (rms)/g (peak) can be produced with a frequency range of from 5 to 2000 cps. Outputs require voltage amplification.

• Temperature—Two types of temperature-indicating sensors are in general use: thermocouples and variable resistance. For rapid response (0.1 sec.) the thermocouple and a voltage amplifier are used. The variable resistance type device has slower response, but greater sensitivity. Used as one active arm of a resistance bridge oscillator, a change in temperature unbalances the bridge circuit and modulates the oscillator.

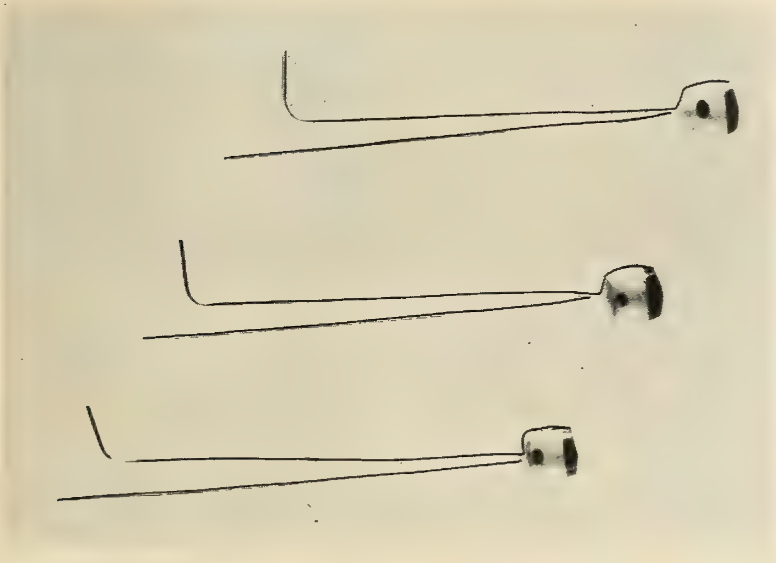
The physical configuration for temperature sensors are extremely varied. Minute sizes are avaliable for insertion into hydraulic systems; grid types for insertion in gas flow streams, etc.

• Strain—Workhorse of the transducer industry is the strain gage, which employs resistance bridge circuitry and falls generally into two principal groups —bonded and unbonded.

Most widely used is the bonded type, developed and patented by **Baldwin-Lima-Hamilton.** The SR-4 gage finds application in measurement of forces ranging from micropounds to megapounds.

The bonded strain gage enjoys a peculiar advantage: it can measure

(Continued on page 48)



Cheaper Selenium Diodes Produced

Designed for volume applications where high reliability, low cost and small size are key factors, new subminiature plastic-encapsulated selenium diodes—priced at only 15 to 35 cents in production quantities—have been developed by **Radio Receptor Company, Inc.,** subsidiary of **General Instrument Corporation,** and are available for immediate delivery.

Capable of operating in ambient temperatures from –50°C. to 100°C with derating, the new Radio Receptor diodes come in eight types, with peak inverse voltage ranges from 50 to 400 volts, at 12.5 ma. Maximum case length is only .380 inches for the 50 and 100 volt units up to .480 inches for the 400 volt type.

Protected from atmospheric conditions by the plastic encapsulation, the new diodes are color coded for simple identification. Bent pigtail and red dot on body of the diode give positive lead indication. The diodes are stated to be priced at least 20 per cent less than nearest comparable units, in quantity. Applications cover a wide range from computers, business machines, arc suppressors, power supplies, etc., to consumer products such as radio and TV sets, hearing aids and electric games.

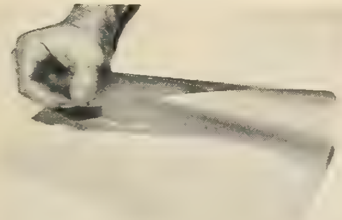
Radio Receptor Company
240 Wythe Avenue
Brooklyn 11, N.Y.

Laminated Plastics Available in New Grades

Two new general-purpose grades of Dilecto epoxy-impregnated, glass base laminated plastics are available from **Continental-Diamond Fibre Corp.**

Designated as GB-28EV-2 and GB-16EV-2, the grades are similar except that GB-16EV-2 is made from a finer weave cloth that permits its use in thinner laminates and for finer machining. Both materials are available as plain sheets or as Di-Clad copper-clad sheets for printed circuit applications.

These new grades are designed for electrical insulation applications requiring high reliability in severe service conditions. In such use they offer low electrical loss properties and good arc resistance and dielectric strength as shown in Table I. Dilecto GB-28EV-2 and GB-16EV-2 also feature excellent tensile and impact strength and good compressive strength. Both grades designated as NEMA G-10 laminates and meet requirements for MIL-P-18177B, Type GEE. Their fabricating qualities are good, with GB-16EV-2 slightly better for close tolerance machining.



The new grades are available in sheet sizes of 38-in. by 42-in. and 38-in. sq.

In thickness, GB-16EV-2 is available in 0.010 in. to 1/8 in. inclusive and GB—28EV-2 ranges from 1/32 in. to 1 in. inclusive. GB-28EV-2 is also available as rolled tubing in sizes from 2 to 12¾ in. ID and 2½ to 13½ in. OD with a minimum wall thickness of ¼ in.

Continental-Diamond Fibre Corp.
Newark, Del.

Transistorized Oscillator Feeds Low Power Units

A millivolt transistorized oscillator, developed by the **Hoover's Electronics Co.** makes it possible to feed the output of low level transducers (such as thermocouples, strain gauges, accelerometers) directly into the Hoover subcarrier oscillator without d-c amplification.

The advantages of eliminating the separate d-c amplifier are fewer packages, with a resulting saving in bulk and weight, lower power consumption, and the elimination of one possible source of error which has plagued telemetering in the past.

D-c common mode rejection is conservatively rated at 10^7 within ± volts of ground. This permits the oscillator to be used with bridge circuits for measuring the voltage between two points in the bridge, without the oscillator's being affected by a voltage from one point to ground.

Floating input terminals eliminate problems which often result from a common ground among several components.

The subcarrier oscillator contains an internal voltage regulator. As a result of carefully designated circuits, its only power requirement is +26 volts. The distortion of the output signal is

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limited to less than 1% by a bandpass filter which also prevents interference with adjacent channels.

The unit is produced to IRIG specifications of frequencies and deviations for channels 5 through 18 and A through E.

Hoover Electronics Co.
110 West Timonium Rd.,
Timonium, Md.

Silicone-Teflon Magnet Wire Operates at +250°

Anaconda Wire and Cable Company has produced Silicone-Teflon Magnet Wire with nickel-plated copper conductors. This is an organic film-coated magnet wire for continuous operation at 250°C.

The Silicone-Teflon Magnet Wire is being used successfully in transformers, solenoids, miniature relays and motors. Experimental transformers wound with Silicone-Teflon were subjected to sufficient load to maintain an average conductor temperature of 250°C and operated continuously for 11,000 hours without failure. Peak temperatures were estimated to be as high as 275°C.

Additional properties of Silicone-Teflon include: low dielectric constant and dissipation factor. Its outstanding flexibility and adherence permits it to be handled in the same manner as conventional film-coated wires. It has excellent resistance to solvent attack by most acids, alkalies and hydrocarbons.

Anaconda Silicone-Teflon wire is available in round sizes, No. 15 AWG through 36, in both single and heavy film thicknesses.

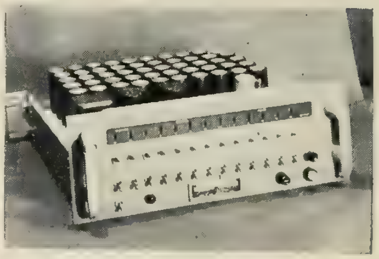
Anaconda Wire and Cable Company, Dept. EFL
25 Broadway
New York 4, N.Y.

Time Reader Features Simplicity

Vitro Laboratories has produced a magnetic tape search unit, the Vitro Model 1060 Automatic Time Reader, which compares the timing or index track of a magnetic tape with switches set to designate the beginning and end of tape sections of interest. Control signals are generated at these times to effect print-out or other desired action.

A "presensing" feature permits generation of the Start and Stop signals precisely at the beginning of a frame of interest and prior to reading time or index code for that frame.

The unit is composed of transistorized, plug-in modules mounted along with the power supply on a 16 inch deep chasis secured to pull out sides for mounting in a standard 19" track. A 7 x 19 inch front panel on the chassis contains the operating controls.



Vitro Laboratories
200 Pleasant Valley
West Orange, New Jersey

Sweep Generators Produce Watts of Power

RF Sweep Generators are now available that will produce watts, rather than milli-watts of power. The new instruments, covering the frequency range from 20 to 1000 mc, are manufactured by **Telonic Industries, Inc.**

Four Telonic Sweep Generators are included in the new line of highpower instruments. Models SP-103, SP-104, SP-105 and SP-106 cover center-frequency ranges of 20-100 mc, 100-250 mc, 250-500 mc, and 500-100 mc respectively. Sweep widths are variable from near zero to over 20% of the center frequency.

The high-power line of Sweep Generators incorporates new concepts in the design of swept RF generators. The two low frequency instruments employ inductively tuned oscillators, while the other two are designed with cavity-tuned oscillator circuits. All oscillators use high-power tubes in order to produce the specified output of over 15 volts RMS into 50 ohms (4-5 watts).

The high-power output is held constant within ± 5% over the maximum sweep width by use of AGC circuits controlling the oscillator B+ voltage.

For load isolation, 3 db pad is provided between the oscillator and the output jack. In addition, there is a vernier attenuator with a range of approximately 0-10 db. Display linearity is better than 1.2:1. Source VSWR for the Telonic instruments is normally below 1.3:1. The sweep rate is fixed at line frequency, 50 or 60 cps. The oscillator is cut off during the return trace in order to provide a zero base line on the oscilliscope image.

The new instruments include the Telonic Birdy-By-Pass Marker system, which provides panel-front jacks for adding beatnotes or birdies to the signal after it has passed through the circuit under test. An external signal of approximately 0.1 volts may be used, or plug-in crystal-controlled marker units may be added to the basic instrument as optional accessories. Provisions are made for up to four "C" type Telonic Markers or two "CDH" type plug-in units.

Telonic Industries, Inc.
Beach Grove, Ind.

Angular Force Balance Accelerometer Available

An angular force balance accerometer is now available from the **Donner Scientific Company.**

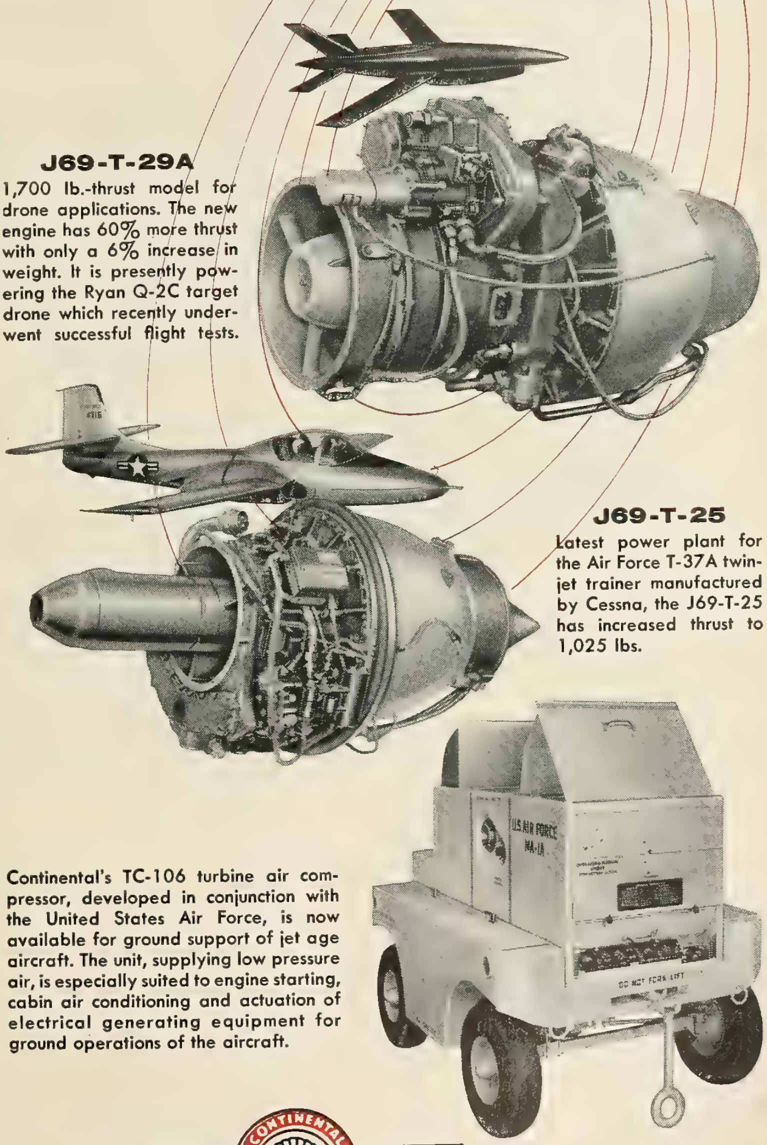
Chief applications for this type of instrumentation are related to missile and aircraft flight dynamics. Pitch, yaw and roll accelerations can be monitored giving information that in some cases eliminates the requirement for more expensive gyro devices. In addition to ballistic and aerodynamic applications, these instruments have been used for various commercial/industrial applications and in ground support equipment.

For instance, visualize a huge radar antenna, perhaps six feet in diameter being oscillated by servo motors at a precise rate. Now introduce wind gusts. Donner angular accelerometers have been used to monitor and to control such devices. They "sense" the gust and feed corrective signals to the antenna servos resulting in the smooth tracking operation of these giant electronic "eyes."

The Donner angular accelerometer operates as a subminiature servo system responsive to input angular acceleration about the sensitive axis. The basic accelerometer consists of a seismic system and associates position-error detector, a restoring mechanism, and a servo error signal amplifier. Under the action of angular acceleration, a force is generated on the seismic system which tends to develop a displacement.

As movement takes place the position-error detector and servo amplifier generates a rapidly increasing feedback signal which is returned as current through the restoring mechanism. With minute deflection of the seismic system, the electro-mechanical servo action of the accelerometer results in automatic balance between the input force proportional to acceleration and the feedback force proportional to current in the restoring coil of the accelerometer. The restoring current, or the voltage it develops across a fixed load resistor, is the electrical output of the instrument.

Donner Scientific Co.
Concord, Calif.



CAE...

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J69-T-29A
1,700 lb.-thrust model for drone applications. The new engine has 60% more thrust with only a 6% increase in weight. It is presently powering the Ryan Q-2C target drone which recently underwent successful flight tests.

J69-T-25
Latest power plant for the Air Force T-37A twin-jet trainer manufactured by Cessna, the J69-T-25 has increased thrust to 1,025 lbs.

Continental's TC-106 turbine air compressor, developed in conjunction with the United States Air Force, is now available for ground support of jet age aircraft. The unit, supplying low pressure air, is especially suited to engine starting, cabin air conditioning and actuation of electrical generating equipment for ground operations of the aircraft.

CONTINENTAL AVIATION & ENGINEERING CORPORATION
12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN

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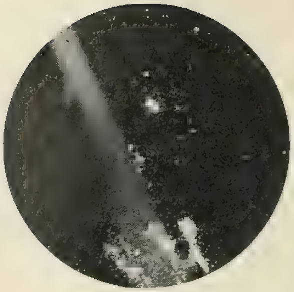

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Box 620-R
Douglas Aircraft Company, Inc.
Santa Monica, Calif.

missile business . . .

By WILLIAM E. HOWARD

Missile contractors in search of new markets—particularly in electronics—should keep an eye on the Army Signal Corps. This agency currently is placing contracts at the rate of $500 million a year. At the moment, it has outstanding 10,000 contracts valued at a total of more than $2 billion. And it has an "open door" policy for new suppliers.

One angle of interest to small business concerns . . .
is the corps' "small business specialist" who maintains a list of recent awards to successful bidders. This list may be reviewed by anyone seeking subcontracts. The list and other contract information is available at:

Headquarters U.S. Army Signal Supply Agency, 225 South 18th St., Philadelphia 3, Pa.; Midwestern Regional Office, U.S. Army Signal Supply Agency, 615 West Van Buren St., Chicago 7, Ill.; Western Regional Office, U.S. Army Signal Supply Agency, 125 South Grande Ave., Pasadena 2, Calif.; U.S. Army Electronic Proving Ground Procurement Office, U.S. Army Signal Supply Agency, Fort Huachuca, Ariz.; U.S. Army Signal Supply Agency, Ft. Monmouth Procurement Office, Fort Monmouth, N.J.; and the Washington Procurement Office, U.S. Signal Supply Agency, Room 2603 Main Navy Bldg., Washington 25, D.C.

Practically all production and industrial . . .
preparedness measure contracts are placed by USASSA headquarters in Philadelphia. These include first time production upon completion of development, and technical representative contracts for the maintenance of field equipment. There is a New York regional branch office of USASSA headquarters, incidentally, at 46th and Northern Blvd., Long Island City 1, N.Y.

The Midwestern Regional Office has sole procurement responsibility for approximately 40,000 items of communications and electronic equipment—from antennas to telephones. No contracts are awarded at Western Regional Office. Its mission is purely to administer contracts with firms in the states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

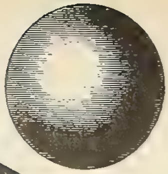
Special equipment contracts for its own operation . . .
are placed and administered at Fort Huachuca. The hot one in the bidding stage now is for a $30-million electronic environmental and missile drone range at the Arizona installation. The contract, to be awarded after Jan. 1, will be for equipment to find out what happens to combat electronic equipment when it is massed on a battlefield. The Army figures that one pentomic division will have more than 15,000 pieces of electronic gear concentrated in a 60 square mile area and there are acute interference problems.

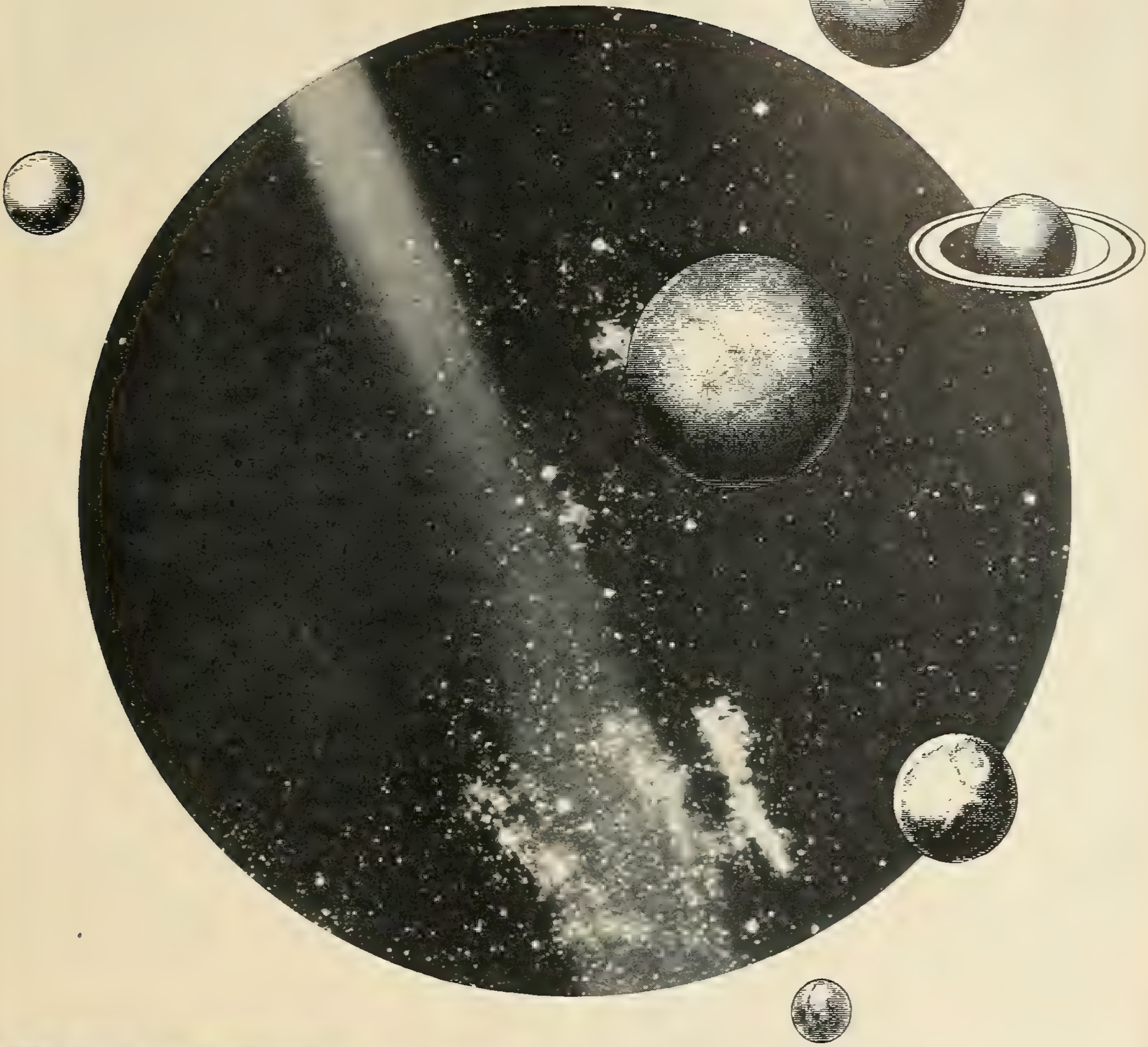
Fort Monmouth processes prime R&D contracts . . .
in communications, radar, surveillance, electrical and electronic components. The initiating agency is the U.S. Army Signal Research and Development Laboratory at Fort Monmouth. Support and housekeeping items are purchased by the Fort's Support Purchases Branch.

No production or military spec contracts are placed by the Washington Procurement Office. Its job, primarily, is to buy standard commercial communications equipment and other services for agencies located in Washington. The Signal Corps also lets contracts for installations and maintenance through the U.S. Army Alaska Communications Systems, 550 Federal Office Bldg., Seattle 4, Wash.

New company divisions . . .
Convair Astronautics has set up a Base Activation Department under Alfred P. Higgins to facilitate organization and management of the logistic support for *Atlas* bases. And **Republic Aviation** has established an Economic Research and Corporate Planning Division headed by Edward Stone. The division will research markets, says Stone, and also "advise on the possibilities of corporate acquisitions."

Biggest thirst in the universe





Each 6,000,000 pound thrust rocket ship now being planned for manned interplanetary exploration will gulp as much propellant as the entire capacity of a 170 passenger DC-8 Jetliner in less than 4 seconds! It will consume 1,140 tons in the rocket's approximately 2 minutes of burning time. Required to carry this vast quantity of propellant will be tanks tall as 8 story buildings, strong enough to withstand tremendous G forces, yet of minimum weight. Douglas is especially qualified to build giant-sized space ships of this type because of familiarity with every structural and environmental problem involved. This has been gained through 18 years of experience in producing missile and space systems. We are seeking qualified engineers and scientists to aid us in these and other projects. Some of our immediate needs are listed on the facing page.

Dr. Henry Ponsford, Chief, Structures Section, discusses valve and fuel flow requirements for space vehicles with Donald W. Douglas, Jr., President of **DOUGLAS**

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND HANDLING EQUIPMENT

people

DOLLINGER

Kenneth Dollinger of Sanders Associates, Inc., has been designated project manager of the target seeker development for the *Eagle* missile. Prior to Bendix Aviation Corp.'s project seeker award, he was manager of a systems section for Sanders.

Dollinger, who joined the company seven years ago following several years of design and development work on missiles, has contributed prominently to advances in seeker systems, countermeasures, navigational devices and missile guidance. In addition to laboratory investigation, development, design, construction and flight testing, he participated in the initial design plans for development of the *Eagle*.

Dr. Nicholas A. Renzetti has been named chief of field tracking and instrumentation, and **Dr. Melvin Gerstein** has been appointed chief of the combustion research section of the California Institute of Technology Jet Propulsion Laboratory.

Renzetti was formerly associated with the Naval Ordnance Test Stations at China Lake and in Pasadena, where he supervised research and development of missile aerodynamics, trajectory determination and other areas of rocket research. At JPL he will be in charge of all deep space tracking stations and the technical communications between these facilities and the laboratory. He has written eleven technical papers and is a consultant to the Air Pollution Foundation, the Naval Ordnance Test Station and General Motors Research Division.

Dr. Gerstein was formerly assistant chief of the Propulsion Chemistry Division, Lewis Research Center. At JPL he will supervise and conduct research in the fields of combustion, chemical reactions in flow systems, and chemical reactions in the atmosphere of the earth and other planets. He has authored 25 technical papers and is well known both here and abroad for his work in laminar flame propagation and on high-energy fuels for air-breathing aircraft.

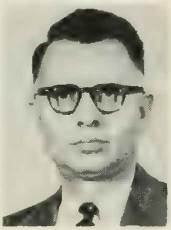
MANOV

Frank Manov, formerly chief scientist to the Allied Air Forces in Central Europe and most recently a senior technical staff member at Space Technology Laboratories, has joined Electro-Optical Systems as supervisor of a newly formed satellite and space defense studies group.

Manov was a senior member of a group responsible for systems engineering and technical direction of the *Atlas, Titan* and *Thor* missiles and a major contributor to recent anti-satellite studies by the Air Force.

Eugene T. Fleischhauer has joined the engineering staff of Poly-Scientific Corp. as senior mechanical engineer, directing special projects for airborne military products.

He was formerly associated with Experiment, Inc., Horace J. Smith, Jr., Inc., and for a number of years with Ordnance Research and Development.


WHITSON

Dr. William L. Whitson, internationally-known authority on space satellite systems, has been named a vice president of Daystrom, Inc.

Dr. Whitson was formerly deputy scientist of ARPA, supervising research and development of military space systems and ballistic missile defense. He was previously associated with the Operations Research office of Johns Hopkins University, the Union Carbide Co.'s Oak Ridge National Laboratory and the Radiation Laboratory at the University of California.

BRISTER

J. E. Brister has been elected to the newly created position of coordinator-defense materials for Union Carbide Plastics Co., division of Union Carbide Corp.

Brister, who joined the company in 1933 as a technical representative, has held positions as manager of the Wire and Cable Division, and department manager, Molding and Extrusion Materials, and most recently served as product general manager-Polyolefins.

Dr. C. G. Harman, with more than 25 years in both basic and applied research, has been appointed senior scientist for Gladding, McBean & Co. He is the author of more than 50 scientific and technical publications, holds many patents, has been affiliated with Battelle Memorial Institute and Locke Insulator Corp. and most recently headed the ceramic department of Horizon, Inc.

Data-Control Systems, Inc., has elected **Raymond A. Runyan** vice president of research and development in telemetry and associated fields.

Runyan, one of the original founders of the company, has written several papers in the telemetry field and directed the development of the line of voltage controlled oscillators, calibrations and ground subcarrier discriminators. He has been associated with Boeing Airplane Co. in the development of non-destructive metal testing equipment, did research on airborne signal processing equipment for Aerophysics Laboratory of North American Aviation and previously designed wind tunnel instrumentations for both United Aircraft and NASA.

The following appointments have also been announced:

Morris Plotkin, formerly with the Naval Air Development Center, Johnsville, Pa., has been named chief of analysis at Auerbach Electronics Corp.

Dr. James Q. Brantley has been named vice president and director of research at Radiation, Inc., replacing Lloyd R. Everingham, who recently resigned.

Robert T. De Vore, former public relations director for the Instrument Society of America, has been named public relations director of Electronic Industries Association.

R. E. "Tim" Dahlin has been appointed sales representative for Transue & Williams Steel Forging Corp., to serve Texas, Oklahoma and southern Kansas.

Republic Electronics Industries Corp. has announced appointment of **Louis F. Lucci,** formerly of Airborne Instrument Laboratories, to the newly created post of assistant purchasing agent.

Alanson W. Parkes, Jr., well known in aviation through 30 years' association with the Aircraft Radio Corp., has been elected president of Ballantine Laboratories, Inc.

Donald C. Harris, previously regional sales engineer for Sperry Semiconductor Corp., has been named West Coast sales manager for National Semiconductor Corp.

David Shapiro has been named to represent Vertol Aircraft Corp. and its subsidiary, Allied Research Associates, on the West Coast.

Sperry Gyroscope Co.'s Sunnyvale Development Center has named **A. W. Lindh** industrial relations superintendent.

Henry Lehne has been elected a senior vice president of Sylvania and will have overall responsibility for electronic systems operations.

Ivan Dornbush has been appointed general manager of Technology Instrument Corp. of California.

Brig. Gen. J. A. Barclay has been named acting deputy commanding general of Army Ordnance Missile Command, Redstone Arsenal, replacing Brig. Gen. J. M. Colby, who has retired.

Lehigh A. Taylor, former RCA marketing executive, has joined Southwestern Industrial Electronics Co. of Houston, in the newly created post of vice president of marketing.

—more about the missile week

• **Groton, Conn.**—Dummy *Polaris* Missiles are now being test-launched from the George Washington, the nation's first nuclear-powered fleet ballistic missile submarine. Initial firings are being conducted while the sub is tied up in the Thames River at the **Electric Boat Division** of **General Dynamics Corp.**

• **Paris**—In the wake of the formation of SEREB (Societe D'Etudes et de Realisation D'Engins Balistiques) by eight French companies to develop missiles and space vehicles, suggestions are now being advanced for the creation of joint research centers by European nations to work in the space field. SEREB was legally organized last month with a capitalization of $1.5 million.

• **Washington**—The AF Air Research and Development Command is now in the process of being reorganized into four functional divisions to cut "substantial time" off the development cycle. These are: the already existing BMD at Englewood, Calif., which will remain under the command of Maj. Gen. Osmond J. Ritland; a new Wright Air Development Division which will consist of the present directorate of systems management and major elements of the Wright Air Development Center; a new Air Force Command and Control Development Division to be established at Hanscom Field, Bedford, Mass., and including elements of the existing AF Cambridge Research Center; and an AF Research Center which will be established in the Washington area and will include the AF Office of Scientific Research, European office of ARDC and other elements of the command engaged in basic research.

• **Washington**—Dr. Herbert York, Pentagon R&E director, conceded that Soviet ICBM's are more reliable than the *Convair Atlas*. York said Russia has been able to develop a more reliable ICBM than the United States because the Russians started work on it earlier.

• **Cape Canaveral**—The Air Force successfully launched three big missiles in 14 hours. An *Atlas* carrying a new fast-re-entry nose cone roared more than 6000 miles down the Atlantic Missile Range Oct. 6. A **Douglas** *Thor* followed it 11 hours later for some 1700 miles. Meantime, an RAF crew launched another *Thor* from Vandenberg AFB, Calif.

• **Ann Arbor, Mich.**—The Navy completed construction of a $600,000 radio telescope that ranks first in the world in the quality of its reception. The telescope—located at the University of Michigan's Peach Mountain Radio Astronomy Observatory—is designed to listen to solar flares and pick up radio emissions from interstellar hydrogen gases in other galaxies.

• **Washington**—Lt. Gen. Bernard Schriever, chief of ARDC, predicted that space between 500 and 25,000 miles from earth will be the "most likely theater" of operations for manned spacecraft well into the future. He also predicted development in the next several years of rockets capable of transporting "very small groups" of men between continents.

• **Washington**—The government announced significant contracts in the fields of nuclear rockets, AICBM's and tactical missiles. NASA is negotiating a $1-million, three-year contract with **Lockheed Aircraft's Nuclear Products Division,** Atlanta, for experiments in connection with a new nuclear rocket system. The research will determine behavior of possible nuclear rocket materials, including liquid hydrogen, at extremely low temperatures while being exposed to radiation. The Army let $188 million in contracts to a **Western Electric** contractor team for R&D on the *Nike-Zeus* AICBM. ARPA and ARDC awarded **Cornell University** a contract to design and build a 1000-foot diameter spherical antenna to be installed in Puerto Rico for anti-missile research. Cost: $4.5 million. **Martin** received a $24-million contract for continued engineering activities on development of the solid-fueled *Pershing* 700-mile surface-to-surface missile.

• **Mare Island, Calif.**—The USS Theodore Roosevelt—third of the nation's growing fleet of *Polaris* launching nuclear-powered submarines—slipped down the ways at Mare Island Naval Shipyard. The ship was the first of the 5400-ton *Polaris* subs to be launched on the Pacific Coast.

• **Dover, N.J.**—The Naval Air Rocket Test Station here has developed a new group of high-energy rocket monopropellants—the two best—"Tallulah" and "Caves." The latter is considered the more stable, weighing more than 95 pounds per cubic foot.

Mergers & Expansions

Ford Motor Co. is opening an advanced R&D facility at Boston headed by Dr. Eric Durand . . . Across the country at Los Angeles, **Perkin-Elmer Co.** of Norwalk, Conn., is opening another advanced R&D operation which will require a staff of 100 . . . **North American Aviation** has completed purchase of its full interest in **Astrodyne Inc.**, McGregor, Tex., from **Phillips Petroleum** . . . **Marquardt Corp.** is adding a $1.2 million building at its Pomona, Calif., division . . . **Lewyt Mfg. Corp.** has been purchased by **The Budd Co.** . . . **Chance Vought** is modernizing its heat treating facility at Dallas to handle refractory metals . . . A new semiconductor plant is being put up at Holmdel, N.J., by **Bendix Aviation Corp.** . . . **Sylvania Electric** plans to construct a 32,000-square foot computer component manufacturing plant at Santa Cruz, Calif., next month . . . Overseas, **Garrett Corp.** has established a subsidiary in Geneva . . . **Burtonwood Engineering Co.,** Lancashire, England, has been acquired by **U.S. Industries Inc.** . . . and at Edinburgh, **Ferranti Ltd.** has expanded its inertial navigation instruments laboratory.

NASA

$54,650—**Avion Div., ACF Industries, Inc.,** Paramus, N.J., for radar beacons.

$47,400—**Gustav Hirsch Organization, Inc.,** Columbus, Ohio, for installation and connection of electrical equipment for reactor facility at Plum Brook, Sandusky, Ohio.

NAVY

$4,700,000—**North American Aviation, Inc., Autonetics Div.,** for additional autonavigators for *Polaris*-carrying submarines.

$1,650,401—**Philco Corp.,** Philadelphia, for technical professional services of electronics field engineers.

$1,250,000—**Packard-Bell Corp.,** for production of airborne radar recognition sets.

$124,435—**Electronics of Clearfield, Inc.,** Clearfield, Pa., for 91 oscilloscopes.

$95,288—**Remington Rand Univac Div. of Sperry Rand Corp.,** St. Paul, Minn., for technical professional services of electronics field engineers.

$79,845—**Telemetering Corp. of America,** Sepulveda, Calif., for services and material to manufacture sonar telemetering system.

$79,685—**Hewlett-Packard Co.,** Alexandria, Va., for H-P model 150A 10mc oscilloscopes, cabinet mount.

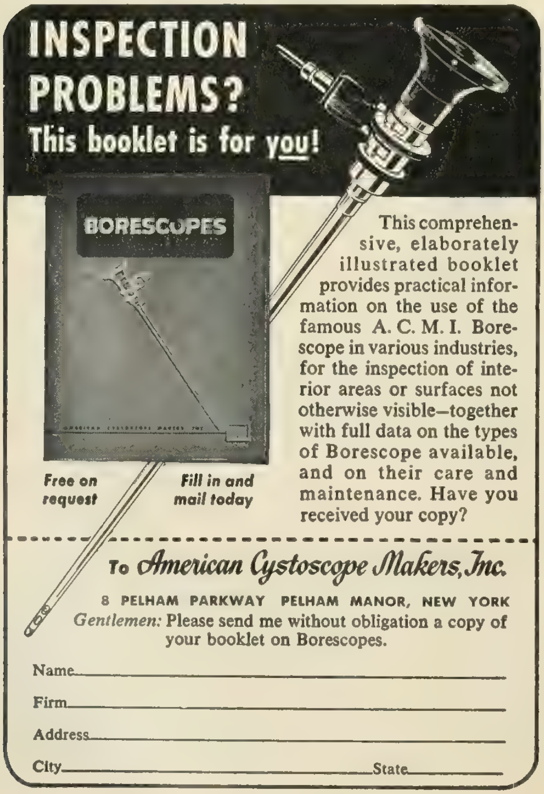
$52,203—**Clevite Corp.,** Electronic Research Div., Cleveland, for developing and evaluating a high-temperature dielectric material for capacitors.

$25,985—**Sperry Rand Corp.,** Long Island, N.Y., for technical professional services of electronics field engineers.

AIR FORCE

Aerojet-General Corp., Azusa, Calif., for the design and fabrication of four *Astrobee-500* sounding rockets. Amount not disclosed.

Daystrom, Inc., for production of power control and marginal checking distribution equipment to be used in the SAGE program. Amount not disclosed.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$15,500,000—**Federal Electric Corp.,** Paramus, N.J., for nonpersonal services to operate and maintain and necessary supply support for the White Alice communication system in Alaska.

$15,200,000—**International Business Machines Corp.,** for five SAGE computers.

$5,268,000—**Continental Electronics Manufacturing Co.,** Dallas, for additional super power radar transmitters for use with BMEWS surveillance system.

$1,500,000—**FXR, Inc.,** Woodside, N.Y., for manufacture of additional DC line type modulators used with the AN/FPS-35 radar set which becomes a part of SAGE. (Subcontract from **Sperry Gyroscope Co.**)

$714,112—**Machlett Laboratories, Inc.,** Springdale, Conn., for various electron tubes.

$300,000—**General Precision Laboratory Inc.,** Pleasantville, N.Y., for components of AN/APN-102 doppler radar sets, spare parts, maintenance tools and test equipment and related data.

$80,150—**Central Electronics Manufacturers,** Danville, N.J., for various electron tubes.

$57,739—**Microwave Electronic Tube Co., Inc.,** Salem, Mass., for various electron tubes.

$44,890—**Ampex Corp.,** Newton, Mass., for recorder/reproducer for instrumentation.

$35,000—**Catholic University,** Washington, D.C. for studies concerning the structure and motion of molecules.

$28,000—**Columbia University,** for conducting a broad investigation of electronic computer-control systems.

$26,372—**Oregon State College,** Corvallis, for performing an investigation of light emission characteristics during early stages of microwave plasma formation.

$25,000—**University of Minnesota,** for conducting basic research in gaseous electronics.

$17,000—**Yale University,** for investigation of various properties of liquid helium.

ARMY

$188,402,905—**Western Electric Co.,** New York, for continued research and development of the *Nike-Zeus* anti-missile missile.

$24,000,000—**Martin Co., Orlando,** for continued engineering work on the *Pershing* solid-propellant surface-to-surface missile.

$2,177,684—**Aerojet-General Corp.,** Azusa, Calif., for 686 *Hawk* missile rocket motors.

$2,154,000—**Chrysler Corp.,** for services and parts for the *Jupiter* missile.

$2,067,138—**General Electric Co.,** Phoenix, for digital computation facility operation.

$1,727,717—**Burroughs Corp.,** Detroit, for production of classified communications units.

$1,313,615—**Sperry Rand Corp.,** for amplifiers to be used in the *Nike-Zeus* development program.

$1,288,211—**Litton Industries of California,** for improvements in the Missile Master systems.

$251,808—**Harvey Aluminum, Inc.,** Torrance, Calif., for study on weapon systems.

$174,462—**Douglas Aircraft Co. Inc.,** Santa Monica, Calif., for *Nike* repair parts.

$127,820—**Central Electronic Manufacturers,** Denville, N.J., for various electron tubes.

$86,183—**Westinghouse Electric Corp.,** Pittsburgh, for investigations leading to the development of photomission solar energy converters.

$67,973—**Tung-Sol Electric, Inc.,** Livingston, N.J., for various electron tubes.

$50,000—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for research and development on concentrators.

$46,811—**Commercial,** Hicksville, N.Y., for feasibility study of an electric timer for use in rocket and guided missile adaption kits.

$43,519—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for research and development work toward investigation of composite or stacted variable energy gap photovoltaic solar energy converters.

$41,268—**Washington University,** St. Louis, for continuation of research on allergic contact dermatitis: Induction of skin sensitivity by low molecular weight substances.

$35,740—**Eagle-Picher Co.,** Miami, Okla., for investigation of integrally composed variable energy gap photovoltaic solar energy converter.

$32,747—**Bulova Research and Development Laboratories, Inc.,** Woodside, N.Y., for study, design and fabrication of nine prototype accelerometer monitors and micro-miniaturized 3-speed synchro assemblies utilizing size 8 synchros for the ground equipment to be used in the *Jupiter* guidance system.

$26,070—**Resdel Engineering Corp.,** Pasadena, Calif., for receivers and local oscillators.

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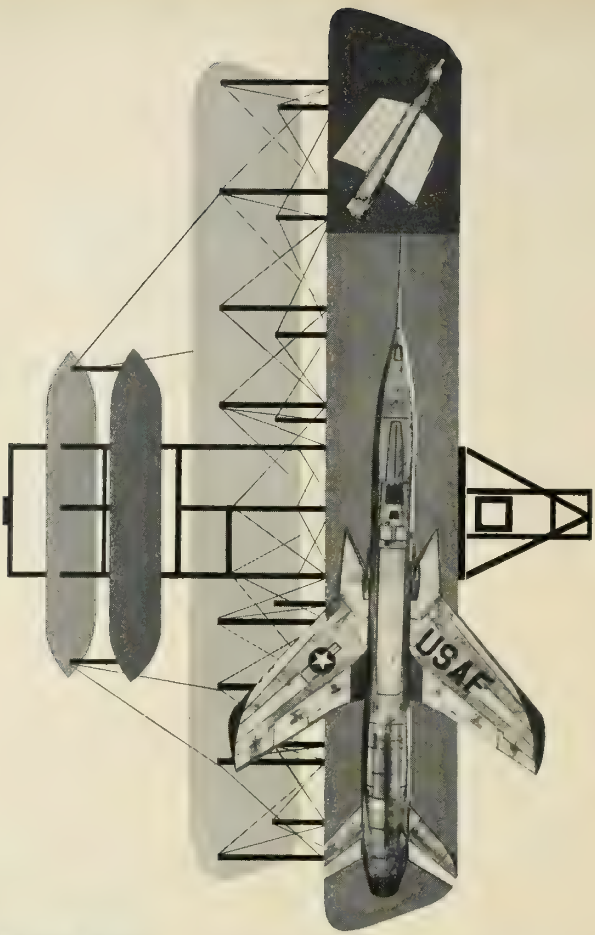
engineers • scientists



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The same holds true for missiles and space vehicles. Thirty brief years ago they existed in only a few imaginations. Today at Republic the imaginations of many men are working to create the vehicles that will allow man to explore the last frontier — space. Included in this far-ranging research and development effort are plasma propulsion systems, electronic and hydraulic subsystems that will operate efficiently in extreme environments, and the calculation of super-accurate space flight trajectories.

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Lunik Orbit Is Longest Yet

by C. Paul Means

WASHINGTON—The Soviet Union apparently succeeded last week in using the moon's gravity force to put *Lunik III* into the most elongated orbit any man-made satellite has achieved.

Present calculations indicate that *Lunik III* will travel over 350,000 miles from earth at apogee and come within 9,000 miles at perigee.

If the as-yet-undisclosed instruments in the Soviet satellite function properly, they will give the first systematic observation of the space between earth and moon. Repeated crossings by *Lunik* of the charged particle belts enveloping the earth should allow scientists to draw a fairly complete and accurate map of these belts. With its orbit extending 100,000 miles (estimated) outside the moon's orbit, the satellite may uncover new phenomena.

- **No moon orbit**—The Russian satellite did not actually orbit the moon. Though the moon's gravitational pull did slow the vehicle, turn it around and head it back again towards earth, the moon will be long-gone by the time the satellite recrosses its orbit path.

Estimated period of the satellite is 18.232 days, with approximately 13 days of the orbit spent outside of the moon's orbit path. Life-time of the satellite is indefinite, though its orbit will be affected by the moon every time it comes within close proximity to it.

The satellite did come close enough to the moon to have taken a crude picture of its back side. The Russians have not announced whether or not *Lunik III's* payload was so equipped, or whether the equipment worked.

Lunik III was launched at approximately 5 a.m. Sunday, Oct. 4, Moscow time. It performed differently than the two earlier Soviet moon rockets in that its speed was purposely slower so that it would be attracted by the moon's gravitational pull.

The soviet approach to moon orbiting as demonstrated by *Lunik III* is markedly different from the American plan, which will attempt to slow its *Atlas-Able* rocket's payload to the desired velocity by firing a retro-rocket.

Unlike the two previous *Luniks*, *Lunik III* did not emit a sodium cloud to aid visual tracking. Speculation is that this mechanism failed to function.

The satellite was powered by chemical batteries replenished by solar cells. The transmitters were turned off in order to save battery power when the satellite was not over Soviet territory. For this reason, U.S. tracking installations have not been able to track it.

Soviet reports said the undisclosed instruments in the satellite were performing "satisfactorily" and that temperature and measuring instruments indicated normal readings of 77 to 86°F and 1.35 atmospheres.

Lunik III made its closest approach to the moon, according to Soviet sources and the world's largest radio telescope at Jodrell Bank, England, at 5:16 p.m. Tuesday Moscow time, when it was approximately 4375 miles from the earth's satellite. The moon was 228,300 miles from earth at the time.

- **Mysterious changes**—Although Jodrell Bank has been able to record most of the signals emitted by the Russian satellite, they will not be able to decode them unless the Russians give them the key. They have not done this in the past.

The scientists at the big English radio telescope were somewhat mystified by the change in the satellite's 183.6 megacycle transmitter's signals during the two-hour transmission period when the payload was closest to the moon.

For the first 20 minutes, according to Jodrell Bank, there was a steady series of 15-second signals separated by 15-second gaps. This was followed by a series of bleep-bleep pulses for 80 minutes, after which the tone returned to the original pattern.

Missile Firepower To Be Shown Off at AF Meet

TYNDALL AFB, FLA.—Air Force jets from around the world later this month will demonstrate the firepower of three air-to-air missiles—the *Sidewinder, Falcon* and *Genie*—at the nine-day annual World Wide Weapons Meet.

The Air Defense Command predicted the first passes alone in the nine days of aerial competition will result an overall score of nearly 90% kill—compared to the 10% kill scores considered good only a decade ago.

North American F-100's and **Lockheed** F-104's will fire the **Philco-GE** *Sidewinders*. **Convair** F-102's will fire the **Hughes** *Falcons*. **Northrop** F-89's will fire the **Douglas** *Genies*.

Both heat-seeking GAR-2 *Falcons* and radar-guided GAR-1 types will be used.

Interceptors throughout the meet—nicknamed William Tell I—will scramble and be vectored to their targets—Q2A *Firebee* drones. Planes carrying TV cameras will provide judges and observers with closeups of engagements.

Reds Urge UN-Sponsored World Space Conference

UNITED NATIONS, N.Y.—The Soviet Union has proposed that the UN junk its existing space committee and set up a UN-sponsored international conference of scientists to pool knowledge secured from space exploration.

In a speech before the 82-member General Assembly, Soviet Deputy Foreign Minister Vasily V. Kuznetsov maintained the Russian stand that the UN committee for peaceful uses of outer space is stacked with Western nations, and hence does not ensure equality in the balance of Communist and "neutral" countries.

He added that establishment of the committee "hindered the start of genuine international cooperation in using outer space."

As an alternative, he proposed: "Taking into account the benefits in exchange of experience in the field of scientific research and accomplishments for a more rapid progress in exploring outer space. The Soviet Government intends, in particular, to put forward the proposal to convene under UN auspices an international conference on exploring outer space."

Czechoslovakia and Poland also hold to the Soviet stand in refusing to participate on the West-dominated committee. The United Arab Republic and India declined joining the committee at its formation on the grounds that its work would be useless and unrealistic without Soviet participation. Because of the Russian opposition, the committee has not been effective.

Early *Little Joe* Test Is Called Full Success

WALLOPS IS., VA.—Man came one step closer to space last week as the *Little Joe* booster rocket passed a firing test with flying colors.

The launching, propulsion and destruct systems all were tested successfully, according to National Aeronautics and Space Administration spokesmen.

The rocket carried aloft a cast-iron model of the Project *Mercury* space capsule which will eventually house the first astronaut. Future tests will carry instruments, then animals, as the program develops. Although last week's mock capsule and rocket were destroyed according to plan 2½ min. after firing, later capsules will be recovered.

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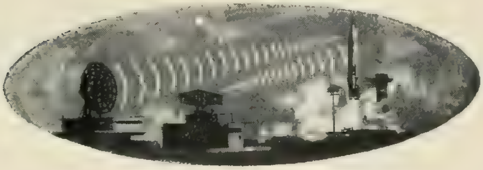

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. . . TRANSDUCERS

(continued from page 36)

either tension or compression; the unbonded can measure only tension. Sensitivity of most units is the order of 2 millivolts output per 1 volt input, full load.

• Today's problems—Problem areas today are much the same as they were a few years back. The need for instruments and materials to operate at higher temperatures, higher g's, in varied and extreme environmental conditions continues, as does the need for more miniaturization and higher reliability.

Increased research must be applied in many fields to meet the expanding parametric horizons.

Gulton Industries feels that there are still two major problems in the refinement of high-intensity microphones —more specifically temperature and vibration. The former limits operating temperature levels. Vibration is a problem because, at low levels, the sound generated by vibration has to be excluded.

To overcome the temperature problem, piezo-electric materials hold forth the best promise since they are now able to operate with stability up to 525°F. Capacitance-type units, on the other hand, are subject to sensitivity changes at elevated temperatures.

The Navy has indicated several urgent needs requiring technological breakthroughs.

It wants a feedback potentiometer designed for use in 1000°F environments. In the past, potentiometers in missile servo systems have broken down at this range; not only does resistance change, but expansion causes binding and solder melts. Space limitations prevent adequate insulation use.

The Navy also wants a strain gage transducer capable of developing an output of from 2-to-5-volts, with direct coupling to a telemeter subcarrier, and without requiring amplification.

Here, the need is for significant weight reduction and reduced circuitry.

Another development long awaited is the digital-output transducer. Many are working in this area, but results have been meager.

To be really useful, the digital output must be an integral characteristic of the transducer. Analog signals currently developed are susceptible to amplitude error pickup. In giving a simple "yes" or "no" response, a digital use inherently would be less error-prone.

• The future—The need for more and different and better transducers appears assured. As some of the problem areas are solved, the distribution of the transducer-market pie may change. Many feel that the missile industry has paved the way for an even greater market in the whole industrial field.

Kearfott Co., Inc. has achieved certain success in developing ferrite magnetostrictive transducers for echo-ranging equipment. Both commercial and military applications are extremely broad and will increase, but continued study will be required.

Vinson Engineering believes that eventually variable reluctance and differential transformer transducers will replace a large portion of the potentiometer market.

Statham Instruments is applying much of its research effort toward developing the concept of a "zero-gage-length" transducer. This is for the distant future. For the near future, Statham is happy with its high-sensitivity ¼-volt output unbonded strain gage transducer, which requires no amplification and has minimum commutation and noise level. They too see a reduction ahead in the potentiometer market.

Another area which shows promise for the future is the application of semiconductors to the transducer field. **Westinghouse Electric Co., Victory Engineering Co.,** and **Bell Telephone Laboratories** are but a few of the many companies active in basic research projects in developing solid state transducers of all types. Strain and temperature sensing devices are receiving the greatest amount of effort.

when and where

OCTOBER

American Institute of Electrical Engineers, Fall General Meeting, Morrison Hotel, Chicago, Oct. 11-16.

National Electronics Conference, sponsored by American Institute of Radio Engineers, Northwestern University, and University of Illinois, Hotel Sherman, Chicago, Oct. 12-14.

Institute of Aerophysics, University of Toronto, Decennial Symposium, Toronto, Canada, Oct. 14-16.

CORRECTION

The University of Denver's Conference on Hypervelocity Projection Techniques will be held Oct. 20-21, 1960—not 1959, as previously reported by M/R. Pertinent papers are invited.

American Standards Association, Tenth National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Oct. 20-22.

Society for Experimental Stress Analysis, Annual Meeting, Hotel Pick-Fort Shelby, Detroit, Oct. 21-23.

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

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Outworn Concept of 'Clobberation'

In the military and in industry these days, long-range planners are spending many long hours over desks and drawing boards trying to find the answer to a question which will affect the lives of every man, woman and child on earth: In the world's arsenal of weaponry, what comes after the intercontinental ballistic missile?

To many, the answer comes in two parts and requires some basic philosophical explanation.

The first-generation ICBM consists of the near-present *Atlas* and the *Titan*. On the way and programmed for 1962 is the second generation, the *Minuteman*. There will be no third generation; in this category of massive retaliation there will simply be refinements, improved guidance, smaller packages and bigger warheads—growing to some 2000 times as powerful as the only nuclear bombs ever dropped in anger.

And somewhere along the line, as the size and accuracy of these and other ballistic weapons improve and as the stalemate of destruction becomes more certain, man will know more and more surely that his old idea of war is outmoded. A world conflict based on devastation, like the horse and buggy, has been overtaken by events.

The concept of clobberation is no good. No one wants to destroy the world.

There is some evidence that the wily Russian may have come to this realization ahead of us; his softening attitude, his reasoned words would seem to indicate it. But since we know by their deeds and declarations that the Communists have no thought of forsaking world domination, we can be sure that the conflict will continue in one way or another.

In the process of abandoning the concept of clobberation (although the present stalemate may be with us for a long time) we turn to other logical possibilities, to the answers arrived at by the planners. Not necessarily in order of likelihood or importance, they are:

1. A struggle to influence and even control men's minds.
2. A race to control space or to deny that control to an enemy.

If we abandon clobberation as a massive weapon, we in effect give up the attempt to control or destroy man physically. The logical next step would be to try to control his mind. This is not a novel idea, of course, but it has never been attempted on the scale possible with today's scientific approaches.

An invisible tranquilizing gas, for instance, spread periodically over a nation could make its people more amenable. In this field of chemical and biological warfare there are dozens of possibilities. The trouble to date has been impracticality of delivery, but this may change.

Another possibility is the computer approach to propaganda. While propaganda is nothing new, reducing it to a near absolute science might be. The known attitudes and reactions of a people, fed in massive quantity into a modern computer, could produce virtually certain answers as to what it takes to influence them, individually and collectively, in what way and to what point.

These are some of the conceivable approaches to thought control. Others almost unbelievably weird are still in the basic research stage.

We are more concerned, however, with the planners' second suggestion as to what may replace the clobberation concept—the race for space. This is not some dream of the future; it is in progress now—and the Russians are both leading and gaining.

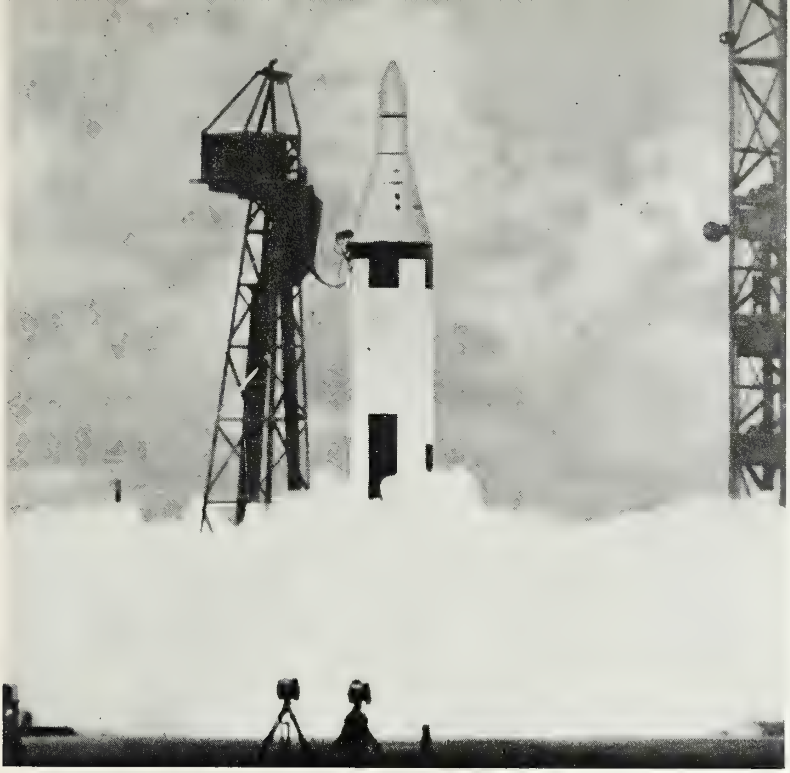
Successes in the race for space have great force, of course, in influencing men's minds. They capture the imagination; their prestige value is incalculable. In a more practical way, they lead toward future control of communications, space experiments, travel, and—conceivably—even the weather.

In a more predatory way, they could break the military stalemate. There is a subtle but terrible difference in being told that the enemy has a force of missiles aimed your way—and in knowing that he has satellite weapons hanging over your head. With such an advantage, the enemy would not have to resort to clobberation, only to the threat of it—blackmail.

Each step in our struggle to conquer space is important, not so much for its immediate value as for its potential. Whether the step is taken by the military or by a civilian agency is not important—an achievement by either can be converted to the use of the other. We have lost two major battles to the Russians, *Sputnik* and *Lunik*.

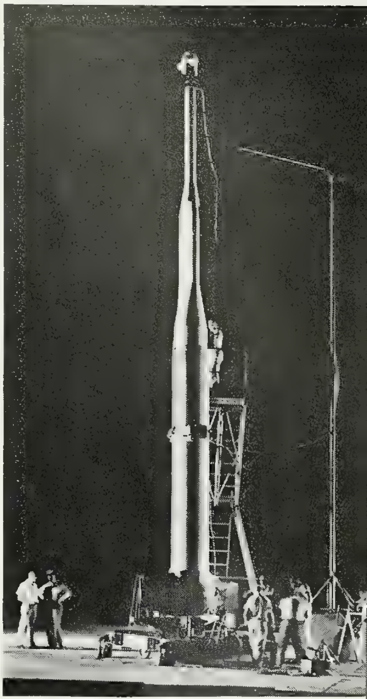
The recent moon orbit may be a third. In our drive to match and excel the Russians, we can afford duplication of effort, even triplication. We can afford backup and multiplication of effort. In fact, there is almost nothing conceivable that we cannot afford rather than the apathy of effort which would permit Russia to win the race and deny us access to space.

CLARKE NEWLON



(left) Navy POLARIS AX-1 flight test vehicle at beginning of launch. Lockheed's POLARIS fleet ballistic missile is more than a year ahead of original schedule.

(below) Nation's first successful re-entry tests were conducted with the Lockheed X-17.



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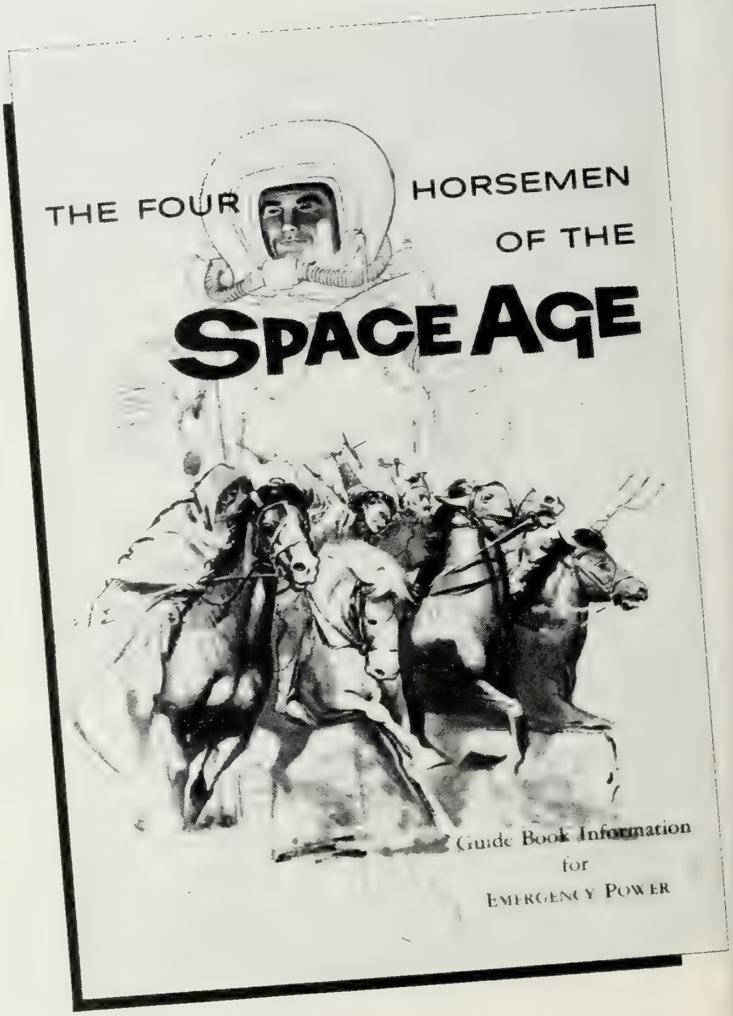

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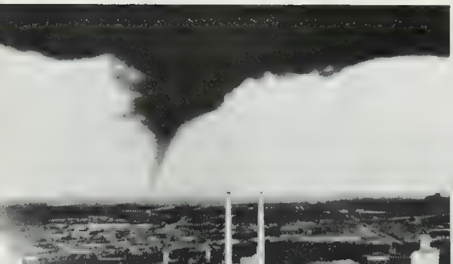

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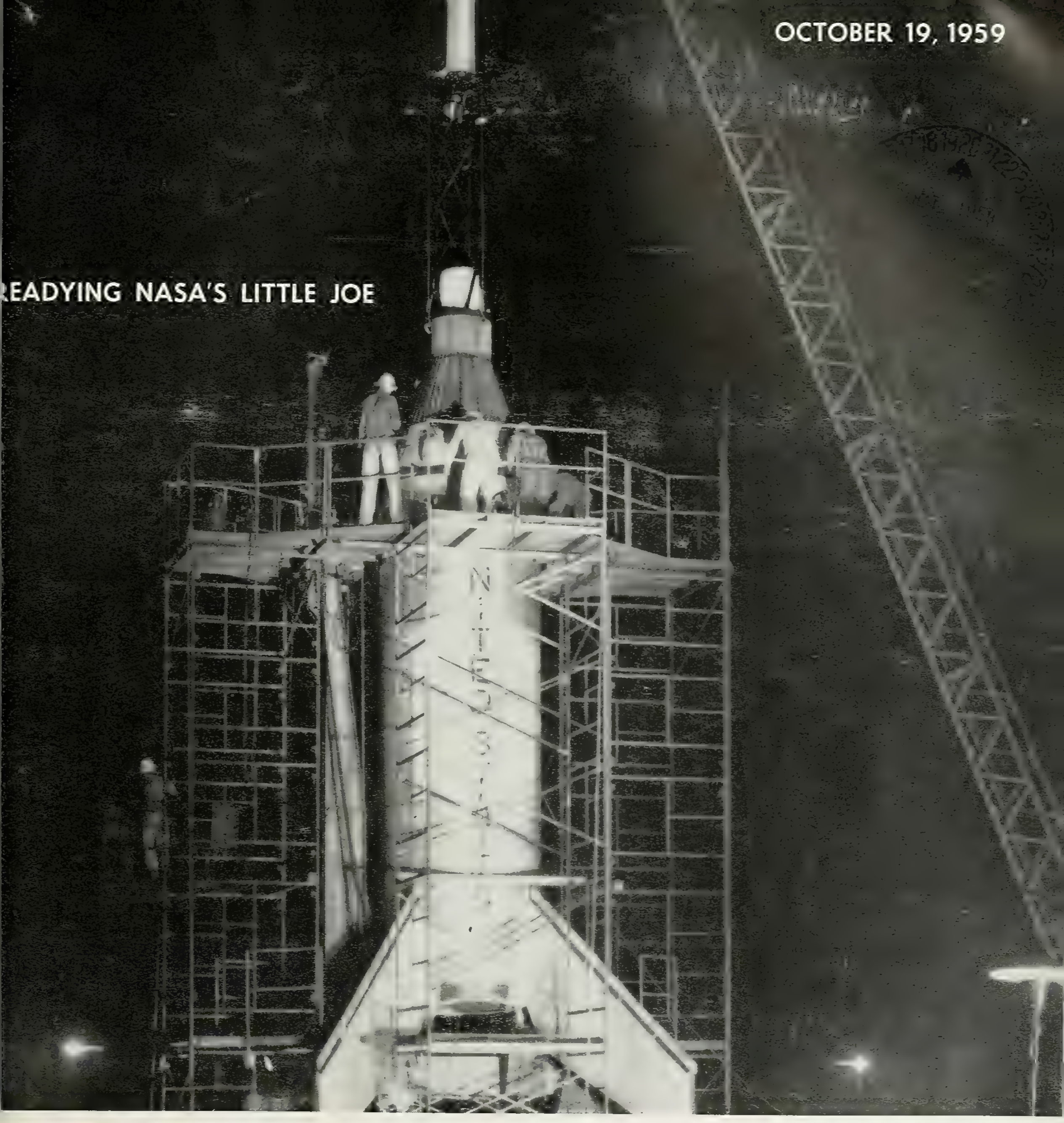

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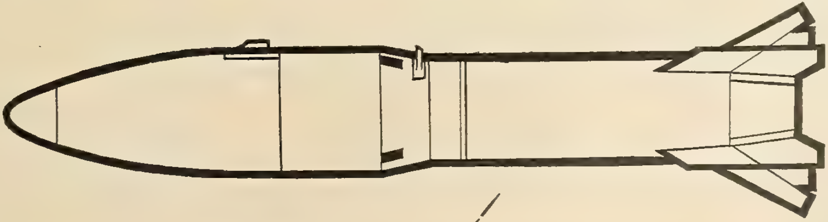

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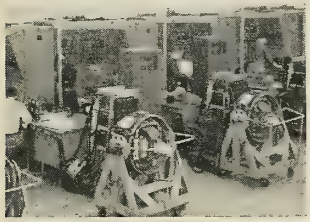
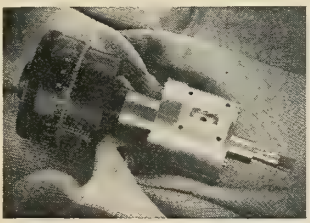
COVER: NASA's *Little Joe* was successfully launched for the first time at Wallops Island, Va., recently. A report on the annual inspection at the Langley Research Center starts on p. 11.



ACHIEVER guidance system undergoes simulated flight tests at AC Spark Plug's Milwaukee labs. The company is a major factor in surging Great Lakes Area missile/space activity. See p. 17.

IRRADIATION of *Regulus 1* by radar mounted on plane on Navy carrier. A report on Navy's Project *HERO*, studying the hazards of R-F radiation, begins on p. 21.



WAVEMETER with precision of about 3 parts in a million was developed by National Bureau of Standards for its broad study of dielectrics aimed at obtaining better measurements and materials. Turn to p. 37.

Lockheed's endless-loop tape recorders

DEVELOPED FOR SPACE COMMUNICATIONS, the recording capabilities of Lockheed's new endless-loop tape recorders are creating interest wherever the need exists for stored data in a critical environment. The original design is now operational in delayed and continuous recording and playback of stored data. Its endless-loop mechanism records and plays back in the same direction of tape travel . . . without rewind. Variations of this lightweight, small size, low power consumption unit are available in a wide range of tape speeds and multiplicity of tracks. For more information on advanced recording techniques to meet your recording needs, write Marketing Branch, Lockheed Electronics and Avionics Division, 6201 East Randolph Street, Los Angeles 22, California.

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Washington Countdown

IN THE PENTAGON

An anti-satellite missile . . .

R&D program is expected to result from the successful Air Force launching of an airborne missile at the *Explorer VI* paddlewheel satellite. The last of a series of **Martin** *Bold Orion* test vehicles roared through the satellite's orbit scoring a deliberate near-miss (within 20 miles). The big question: Will the Air Force seek development of a separate anti-satellite missile or try to give the **Douglas** *ALBM* a dual role?

• • •

The next *Transit* . . .

satellite is still scheduled to be launched in late winter (M/R Oct. 12). Top officials say reports of plans for earlier launchings are erroneous.

• • •

New space radiation studies . . .

2000 miles above the earth will be conducted by the Air Force during the next three months. **Aerolab Development** *Journeymen* will carry 115-pound payloads through the Van Allen radiation belts. The last of three Aerolab *Javelins* also will be fired 1000 miles above the earth with the same size payload.

• • •

A second-stage snag . . .

that caused a *Polaris* test vehicle to fall short of a planned 900-mile flight Oct. 12 apparently was a random failure resulting in loss of pressure. The test-vehicle was the second of the new 900-mile series. The first went the full range.

• • •

Discoverer trouble . . .

is believed to have been solved. ARPA scientists have corrected what they think has caused repeated failures in recovering *Discoverer* satellite capsules from orbit.

ALONG EMBASSY ROW

The Turkish IRBM base . . .

being planned by the United States and Turkey is expected to be armed with **Douglas** *Thors*. The Turks are expected to be given one 15-bird squadron. The 1500-mile range *Thors* would be capable of hitting most of European Russia and Western Siberia.

• • •

The first French IRBM . . .

will have a solid and packaged-liquid propellant so that it can be installed in hardened sites. The French are expected to shoot for a 2000-mile range.

A Philippine missile base . . .

apparently is being sought by the United States. It probably would be used for deploying **Martin** *Matadors* or *Maces*—both capable of striking the Red Chinese mainland from the Philippines with big nuclear warheads.

AT NASA

Wings may sprout . . .

on the Project *Mercury* capsule. Engineers are seriously considering using them in order to ease re-entry. The wings probably would be foldable.

• • •

Wanted: More data . . .

on aerodynamic heating of the *X-15* rocket plane in full-scale free flight. So far scientists have been unable to get all they want to know about it in the laboratory. They expect to have to go to the real thing to get the answers. Some 650 thermocouples have been placed throughout the rocket plane to record temperatures.

AROUND TOWN

The Martian-made satellites . . .

that some Russians believe may be orbiting the Red Planet are not getting the ha-ha from a number of U.S. scientists. Even scientific speculations labeled "made in USSR" get respect these days.

• • •

Worried U.S. space lawyers . . .

continue to try to get the Administration to worry about future Soviet space claims. The legal experts warn that time is running out for reaching agreements on such problems as who owns the moon and when is a reconnaissance satellite not a Peeping Tom.

• • •

Some of the reports . . .

being passed as "the latest" in the nation's capital:

. . . The government is showing an increasing interest in the shipping of cargo by air-breathing missiles.

. . . The Russians are considering launching a spacecraft with two men and two women on a "one-way" trip around the moon.

. . . The pressure is on to kill the development of the solid 700-mile-range *Pershing*.

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11-1

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Industry Countdown

MANUFACTURING

Market for a variety . . .

of short-range, air-launched missiles may be created by successful firing of **Nord's** wire-guided anti-tank *SS-10* and *SS-11* from U.S. Army helicopters and fixed-wing aircraft (See p. 26). Army has 6000 recon air vehicles, many of them capable of providing close-in troop support with missiles.

• • •

French *Masurca* and *Malafon* . . .

missiles will be used to equip the country's first 5000-ton "pocket" missile cruiser. *Masurca* is surface-to-air and *Malafon* is an ASW surface-to-underwater missile. The French Navy decided to go ahead with *Masurca,* although similar U.S. missiles have better performance, because existing ships would have to undergo major modification to accommodate U.S. guidance systems. The Navy also doubts whether U.S. missiles can be manufactured successfully under license by French industry.

• • •

Japan now has four . . .

missile development teams. The latest, formed last month, brings together six Mitsui Group companies into the Missile and Technique Research and Development Group. The members—**Tokyo Shibaura Electric, Fuji Heavy Industries, Japan Steel Works, Dai Nippon Celluloid, Tokyo Instrument** and **Mitsui & Co.**—will use **Raytheon** *Hawk* for research.

• • •

Latest addition to ASW . . .

field is **Avien Inc.,** Woodside, N.Y., which is forming a new Department of Undersea Technology. Heading up the undersea instrumentation and propulsion effort is former **Fairchild Engine & Airplane Co.** USW expert Woodford M. Rand.

PROPULSION

Fuel injector . . .

of **Rocketdyne's** 1.5-million-pound-thrust single-chamber F-1 engine has been tested above one-million pounds thrust. Kerosene and LOX were pumped into the combustion chamber at the rate of three tons per second. Combustion generated temperatures in excess of 5500°F.

Standing idle . . .

Rocketdyne's 400,000-pound-thrust single-chamber E-1 engine. The Air Force says it hasn't any immediate requirement for it and, apparently, NASA hasn't the money to put a vehicle around it—even though the engine might be a major asset to the nation's faltering space program.

ASTRIONICS

Sequel . . .

for its ALBM guidance, **Douglas** last week picked the **Nortronics Division** of **Northrop Corp.** M/R reported July 6 (p. 11) ALBM specs would demand "complete digital system for stellar acquisition, interpretation and readout measured in seconds rather than minutes. Manufacturer who produces quickly, therefore, has a lucrative opportunity." At that time, for security reasons, M/R withheld the fact that Nortronics had such a system already in being.

• • •

'Second-source' . . .

procurement policy of DOD is taking the motive out of company-paid efforts to produce better missile components. Military officials have held up acceptance of improved devices—in one case a miniature servo motor—until a competitor is found who can make the same item. Thus, the originator loses the advantage bought by his R&D investment.

• • •

Getting tiny motors . . .

to operate at high temperatures is mostly a problem of improved lubrication. However, demand for this type of heat-resistant oil would be so small, it wouldn't pay the R&D cost—a mounting problem in miniaturization.

WE HEAR THAT—

Bell Aircraft officials . . .

are labelling the rumor (M/R Oct. 5, p. 13) that Dr. Walter Dornberger may leave Buffalo for a Washington job as "extraordinarily remote from the truth." Dornberger will stay at Bell . . . Year-old **Missiles & Space Division** of **United Aircraft** has landed Navy contract for *Talos* booster fins and an AF award for studying ballistic missile defense equipment . . . **Texas Instruments** is denying in court charges brought by **Sperry Rand Corp.** that TI infringed on Woodyard Patent No. 2,530,110 for germanium diodes.

More About the Missile Week on Page 45

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At Langley Inspection . . .

NASA Stresses Winged Re-entry R&D

Week-long event is highlighted by attention given to winged vehicle research and by new trends in structures, shielding and propulsion

M/R Staff Report

LANGLEY FIELD, VA.—Space scientists of the National Aeronautics and Space Administration last week gave the missile industry an insight into the structure, materials, design, propulsion and communications systems of future space vehicles.

Keynote of the 1959 NASA inspection at the Langley Research Center was that astronautics research must now be extended to solve the problems of returning winged vehicles from the space environment.

Major portions of the week-long inspection attended by more than 2000 representatives from government and industry were devoted to research reports on winged vehicle re-entry feasibility. Project *Mercury* scientists intimated that this nation's first manned satellite capsule may sprout wings before it goes aloft.

Lectures that were of particular interest to the missile and space industry included:

- **Manned re-entry vehicles**—Glider configurations will replace capsules as manned re-entry vehicles as soon as they can be stabilized as payloads on top of rocket boosters, and as soon as materials are available to protect their leading edges from the severe heat of re-entry.

Langley Research Center scientists pointed out that the lifting capability of a glider configuration would greatly reduce the g force stress on the astronaut during re-entry.

Another advantage of the glider vehicle, according to Langley scientists, is the wider corridor within which it can re-enter the earth's atmosphere. A capsule returning from space must be in a corridor only seven miles wide. If too high, the capsule will re-escape into space, and if too low, will experience severe deceleration.

A glider configuration, however, would have a corridor 60 miles wide.

- **Re-entry physics**—NASA's effort in re-entry physics is principally in two areas: The first concerns the effects of ionization on electromagnetic radiation and the second is concerned with research on advanced materials and systems suitable for thermal protection under conditions of extreme heat.

ENGINEER checks valves on cutaway, full-size model of NASA's 6000-pound thrust *Vega* rocket vehicle.

A "plasma sheath" is formed from the ionized gas by a re-entry vehicle. This "sheath" acts as though a metallic shell is covering the vehicle and problems arise when the vehicle's transmitter attempts to contact the ground. Telemetry signals can be completely cut off by severe ionization.

The ionized shell also gives a radar appearance that is much larger than the vehicle. Though the larger blip can be an aid to radar detection, it hampers interpretation of the radar signal.

- **Structures**—In the field of structures research, NASA showed it was not at a loss to come up with proposed new vehicles or the laboratory conditions needed to simulate their environment.

The space agency demonstrated for the first time a re-entry condition simulator made up of two devices which apply high heat and heavy loads to glider-type configurations. The radiator is a quartz-lamp heater in the shape of a re-entry glider wing. Aerodynamic loads are simulated by hydraulic jacks acting on the structure. Gold plated reflectors direct heat from the quartz lamps toward the test model, and 400 transducers, strain gauges and thermocouples measure reaction of the structures to the heat—up to 2500°F and loads.

NASA said that the time a vehicle would spend at temperatures greater than 2000°F is expected to be of the order of five minutes in a total re-entry heating period of approximately 20 minutes. After 20 minutes the glider is expected to slow to a speed at which aerodynamic heating is not a significant problem.

- **New shields**—NASA also gave details about two new types of heat shields which should have superior qualities over the heat sink and ablation types presently in use.

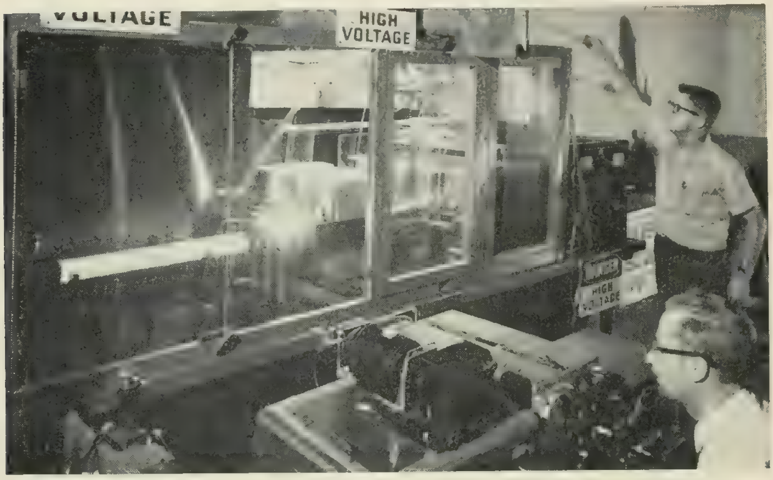
An insulated design uses an insulating material which is held in place by a thin metallic outer skin which is corrugated to provide a means for absorbing thermal expansion and to provide sufficient stiffness to prevent flutter. The design can be fabricated from refractory metals such as molybdenum, niobium or tungsten.

This type of heat shield would reduce the lower surface load carrying structure's temperatures of a glider re-entry vehicle to 1200°F when heat shield surface temperatures are 2500°F.

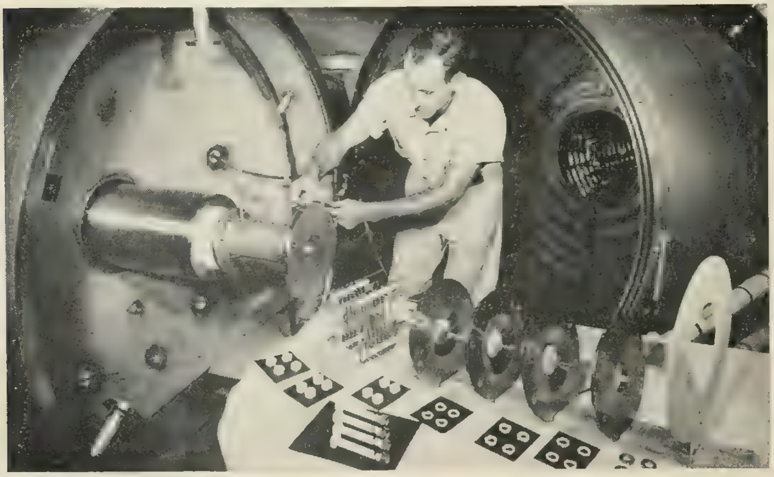
An even better shield, according to NASA, is an insulated structure with added heat absorbing capacity gained by the storing of water in the channels formed by the stiffeners in the structure. Structure temperatures could be held down by this shield to the temperature of boiling water (200°F).

Temperatures in excess of 3000°F in the nose and leading edges of re-

AT LANGLEY Research Center's 11-inch hypersonic wind tunnel, models used include basic flow and heat transfer wing, wing-body combination and re-entry vehicles.



SEQUENCE CAMERA (foreground) is used at Center to observe test of plasma accelerator studying some of the basic physical phenomena of ionized gases.



ION ENGINE research model is assembled in the High Vacuum Test Facility at NASA's Lewis Research Center, Cleveland. The engine operates with cesium propellant.

entry gliders will be coped with by ceramics and refractory materials. Two methods of constructing leading edges were given: a radiative approach and an ablative approach.

The radiative method uses materials in short segments with expansion joints because of the high thermal gradients involved. They are attached to the glider structure so that expansion is not restrained by the supports. Most of the heat is radiated into space, and only a small fraction passes through the insulation and is conducted to the glider structure.

The second method absorbs heat by melting and vaporizing leading edge materials. Graphite, NASA said, is a promising material for leading edge constructions although it has an undesirable large amount of surface erosion due to surface oxidation, which could be corrected by protective coatings such as pyrolytic graphite.

- **Propulsion**—NASA's Lewis Research Center unveiled two types of electric propulsion systems which hold great promise of supplying the continuing jet velocities needed for deep space interplanetary missions.

Both systems create low-thrust but high-jet velocities by the ionization of atomic elements by removing one electron from the atomic mass, giving them a positive charge.

Lewis scientists unveiled a small scale ion engine capable of producing an ion or plasma velocity of 60,000 feet per second. Though it is not powerful enough to have any present space application, Lewis technicians are confident that electrical propulsion systems using the ionization process will be capable in the near future of producing jet velocity values of 216,000 mph.

Lewis scientists feel that the element with the greatest possibilities for electric propulsion is cesium because the electrical energy needed for its ionization is low.

The two methods demonstrated creating ion propulsion using cesium were an electrical conductivity engine and an ion engine.

The electrical conductivity engine induced electrical current to pass through the plasma or ionized gas in the presence of a magnetic field. The resulting force—similar to that used to turn an ordinary electric motor, propels the space vehicle. The current heats the propellant, vaporizing and ionizing it, and at the same time, produces a magnetic field by running through the back electrode. The ionized gas, or plasma, is then accelerated by the combined effect of the magnetic field and the electric current, and moves out of the chamber.

The ion engine injects cesium into

a boiler, where temperature controls the vapor pressure and the flow rate. When the cesium vapor impinges on the hot tungsten grids, it becomes ionized and is accelerated out of the rear of the chamber by electrodes. As the stream of ions leaves the engine it is joined by a matching stream of electrons shot out the rear by an electron gun so that the beam has no net charge.

Lewis scientists operated a small ion engine within a bell jar, but pointed out that larger ion engines at the research center had obtained ion beams up to 12_0 ma at 10KV, a thrust of about 1/16 pound.

- **Magnetoplasma dynamics**—Supplementing the Lewis Laboratory's work on electrical propulsion units is the Langley Research Center's basic research into the concept of magnetoplasmadynamics.

This unwieldly term defines a new branch of physics which devotes itself to the study of electrically conducting high-temperature gas or plasma.

Besides MPD's applications in space engine development, there is reason to believe that the principle may be used to generate radio waves in space and to produce commercial electric energy.

Another effect of MPD, noted above, is the ionized shell that surrounds an incoming ICBM nose cone or a space vehicle during re-entry.

As a source for microwave communications, Langley scientists predict that microwave velocities of the order of millions of miles per hour should be possible.

Other practical applications of MPD include plasma accelerators for hypersonic wind tunnels, and powerful commercial electric generators.

- **Hypervelocity impacts**—The Ames Research Center's scientists gave some details of laboratory studies to develop lightweight structures which will be capable of resisting catastrophic damage by impact of space debris.

To simulate a phase of interplanetary environment where an object is bombarded by atoms and actual erosion occurs, Ames Laboratory scientists have developed a "particle accelerator."

This beam of high-speed atoms and molecules has been directed at various materials suitable for spacecraft. Bombardment of a copper surface simulates erosion which would take place in one year for a 300-mile orbit or hundreds of years for interplanetary space travel.

- *Vega*—The **Jet Propulsion Laboratory** demonstration revealed publicly for the first time what the ingredients of the 6000-lb.-thrust encapsulated liquid 6K third stage *Vega* engine were, and how the JPL-developed *Vega* inertial guidance system works.

The storable third stage *Vega* engine, now under development by JPL, uses nitrogen tetroxide as the oxidizer and hydrazine as the fuel to produce its 6000 pounds of thrust. This is the first practical application of this oxidizer and fuel in a propellant system.

Because of its encapsulation technique, JPL claims that the 6K engine can be loaded weeks ahead of time, will lie dormant and not even be a part of the final launch countdown.

The *Vega* guidance system, contained in JPL's third stage, is inertial and provides commands to the booster and the second stage. It has the capability to compensate for unsuitable firing locations by not firing the third stage until it is in the proper location to complete a given mission.

This is done by putting the second stage of the three-stage vehicle into a "parking orbit." Then the third stage fires the payload out of the satellite orbit when it is in the proper position to complete a lunar or other exacting and difficult deep space missions.

"In other words," according to the JPL spokesman, "we place the second stage over that part of the earth where we would have like to have had the launching pad, and we have fired from that point."

- **Space R&D**—Spokesmen for the newest space research organization in the NASA family—the Goddard Space Flight Center—told the NASA Inspection audience what its future role in the civilian space program would be.

Made up of a combination of older existing organizations such as the Naval Research Laboratories' *Vanguard* team, the Army's Signal Research and Development Laboratories, and NASA's Project *Mercury* team, the new organization will devote itself to R&D on future manned satellites, on space science and satellite applications, and on the tracking and data systems needed for future space research.

The Goddard Center's work in manned space flight includes the Project *Mercury* program, designed to orbit the first man into space.

House Group Agrees With Shutdown of Boron Plants

WASHINGTON—The House Space Committee agreed with the Defense Department's decision to shut down the Model City, N.Y., and Muskogee, Okla., production facilities for high-energy boron fuels.

The technological advances in missiles, the subsequent shift in weapons systems and the increased aerodynamic performances of aircraft were some of the factors involved in the decision.

Members of the Committee were dissatisfied with the Defense Department's management techniques employed in making the final decision regarding the high-energy fuel program. The Committee felt the decision could have been made sooner.

A considerable increase in the total cost and the heavy impact on the industries and communities involved were a direct result of the delay by DOD in recognizing the changing requirements of the "ZIP" fuel program.

The Committee called for a firm national program in boron fuels to preserve the scientific teams formed over the past ten years.

The House Group recognized that the boron production facilities were in support of a highly speculative research and development program and do not desire to make any statement which would affect any national research and development effort.

String-type Igniter Adds Speed, Uniformity

WILMINGTON, DEL.—A new string-type igniter, "Pyrocore" has been developed by **DuPont** to answer the need for faster and more uniform ignition.

Essentially a small-diameter, continuous metal tubing containing a detonating-ignition core, the device may be initiated at either or both ends by electrical or other means.

The string-type igniter, insensitive to ordinary shock, can ignite wet, dirty, or otherwise inhibited rocket grains because of its ability to scour the prepellant with the minimum residue produced.

Tests show that certain types of "Pyrocore" can be detonated in small, eight-point rocket grains with less brisance than a standard squib plus metal/oxidant igniter.

Once the end primer is applied, the sections not intended for ignition purposes may be encased or potted in practically any substance.

Thiokol Chemical Opens Solid Propellant Plant

MARSHALL, TEX.—New solid propellant facilities, operated by **Thiokol Chemical,** will meet present motor requirements and are capable of producing the *Pershing* and *Nike-Zeus* propulsion systems.

Dr. Harold W. Ritchey, Technical Director of Thiokol, said that rocket motors currently in production here could land an object on the moon if used in the proper combination.

Lt. General John Hinrichs, Army Chief of Ordnance also states that the Longhorn Works could be used by the three services interested in solids.

Thiokol's *Minuteman* first stage was successfully fired recently at Edwards Air Force Base, California, in a silo test shot.

While Soviets probe moon . . .

Fund Shortage Delays *Saturn* Program

ABMA Chief Medaris reports money bind caused delay of first static test from December, 1959, until next spring; President weighs agency's status

by Jay Holmes

WASHINGTON—The test program for the *Saturn* booster, America's best hope for catching Russia in the race for space, has been delayed by a fund shortage, Maj. Gen. John B. Medaris declared last week.

Medaris, commander of the Army Ballistic Missile Agency at Huntsville, Ala., said the money situation has delayed the first static test of the booster from December, 1959, to some time in the spring of 1960. First flight tests are planned for 1962 or 1963.

Saturn is a cluster of eight liquid-fueled **Rocketdyne** engines of the type used in the *Jupiter* and *Thor* missiles. The cluster is to develop 1½ million pounds of thrust, compared with the 500,000 to 800,000 pounds in the boosters that lifted the Soviet *Luniks.*

ABMA is developing *Saturn* under contract to the Advanced Projects Research Agency of the Department of Defense, with a current budget of $70 million. An ABMA spokesman said the original request to the Defense Department was for about $135 million.

ARPA officials agree it would be possible to speed the *Saturn* program. But they question whether it would be desirable. The cold facts are that *Saturn* last month just barely survived a proposal that it be killed. Any idea that Defense Department money might be allocated to speed the development seems to be completely out of the question.

Why is this so? The answer is simple. The armed forces are in the business of national defense. There are many military tasks that a big booster rocket can perform. But none of these is needed before the 1963-5 time period. And so, ARPA spokesmen point out, it doesn't make sense to spend extra military money on a crash program to develop a booster rocket sooner.

• **NASA's job**—Furthermore, the armed forces have no official mission in space. Exploration of the region beyond about 600 miles up is the task of the National Aeronautics and Space Administration, a civilian scientific agency.

"*Saturn* is a part of the national booster program," the ARPA spokesman said. "Our requirements are military. NASA's are scientific. But the decisions are made on the political level." He continued:

"If there is any scientific or political need to develop this booster faster, it hasn't been communicated to us. We have received no such request from NASA or the State Department or any other government agency."

On the purely political level, of course, the *Saturn* program has been the subject of several suggestions and requests. A scientist on the staff of Sen. Stuart Symington, Missouri Democrat, proposed last week that an additional $100 million be transferred to the *Saturn* program. The scientist, Dr. Edward Welsh, said the money could be used to speed testing.

What is NASA's position on *Saturn*? Officials of the space agency say it is a Defense Department project and that any comment by them would be improper.

• **Delicate situation**—A factor underlying the NASA reticence is the doubtful status of ABMA. The Defense Department announced last month that the Army is getting out of the space business. Dr. Herbert York, defense director of research and engineering, said he expected ABMA would eventually be transferred to the Air Force. More recent reports indicate that the idea of a transfer to NASA may be gaining ground.

Washington Name-Dropping

WASHINGTON—*The National Aeronautics and Space Administration has quietly dropped the name* Nova *for its 1½-million-pound liquid engine under development by* **Rocketdyne.**

There now is no official code name for the project. Rocketdyne calls the engine simply "F-1."

"We just didn't like the implications of the word nova," a NASA spokesman commented.

A nova in astronomy is a star that explodes.

In such a delicate situation, neither NASA nor Air Force spokesmen are making any statements that might tip the balance.

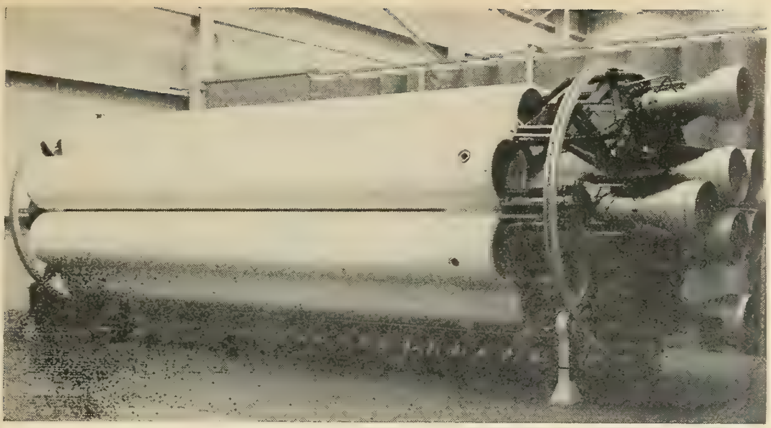
The decision, of course, is up to President Eisenhower. But it cannot take effect without at least tacit approval by Congress. The Space Act of 1958 provides that any transfer of an agency involved in the space program may not take effect until the passage of 60 days during which Congress is in session. The act gives Congress power to veto such a transfer by a joint resolution.

To assist him in making his decision, the President has the advice of the National Aeronautics and Space Council, composed of the secretaries of defense and state, the NASA administrator, the Atomic Energy Commission chairman, the director of the National Science Foundation, the president of the National Academy of Sciences and two non-government members. John T. Rettaliata, president of the Illinois Institute of Technology, is one of the latter. The other non-government post is vacant.

The law specifies that the President is chairman of the council. However, President Eisenhower's scientific adviser, Dr. George B. Kistiakowsky, has been sitting in for the President at some council sessions.

• **Decision time**—There were reports last week that the question of ABMA's status has reached the White House and that a decision is expected soon. However, since Congress is not in session, any decision could not take effect until March at the earliest.

Obviously, the funding and the schedule of the *Saturn* program depend on this White House decision. This in turn depends to some extent on the concept of America's activities in space.



SATURN **MODEL: A quarter-scale version of the clustered engine with 1½ million pounds thrust being developed at Huntsville.**

The question of whether we should engage at all in a race with the Soviets is far from settled.

The scientists who are advising the President decline quite properly to say what advice they are giving. However, it is logical to assume that they are influenced by the current trend of opinion within the scientific community.

Many influential American scientists doubt we should spend the money necessary to race with the Soviets into space. They feel that the government money available for scientific research could be better spent in other areas. The National Academy of Sciences recently recommended a large increase in oceanographic research. Others think we could support more medical research. Dr. Dael Wolfle, executive officer of the American Association for the Advancement of Science, explained the situation as follows:

• **Costly experiments**—"I think there are people in the scientific community who feel that the money it takes for a major shoot into space would be better spent for a systematic program of sea-bottom coring or to solve fairly specific medical problems. The Van Allen radiation belts and the results of the *Argus* experiments are interesting but tremendously costly. We may get more scientific results from other, less expensive, programs.

"Of course," Dr. Wolfle added, "we must realize that, to a large extent, space science is riding along on military developments. So it is not fair to charge all of this cost off to science."

He agreed that some of the cost can be charged to national prestige. But he added: "There is never as much prestige involved in catching up as in doing something else."

A possible "something else" is the Project *Mercury* man-in-space program. Dr. Homer J. Stewart, NASA director of program planning and evaluation, told an interviewer last week that *Mercury* still has first priority on the space agency's list of jobs to be done.

Stewart said *Mercury's* priority was the reason underlying the NASA decision not to have a backup *Atlas* booster available in case something went wrong with the booster assigned to the *Atlas-Able* moon shoot. That was scheduled for early this month, about the same time the Russians fired *Lunik III.*

Some military men have criticized the NASA decision, saying that a reserve vehicle should have been on hand for an experiment that carried so much national prestige. The shot, an attempted moon orbit, was postponed after the assigned *Atlas* exploded during a static test late in September.

• **No spares scheduled**—On this criticism, Stewart commented: "We don't have so many *Atlases*. Every one available has a significant use. They are not scheduled as spares."

Security considerations forbid disclosure of either the total number of *Atlases* available or the number assigned to NASA. Every one that comes off the production line has an assigned use long before delivery. Stewart said: "We have to decide now on our *Atlas* needs two or three years hence."

The *Atlas,* with a total of 360,000 pounds of thrust, will play a large part in our space program until *Saturn* is ready. In addition to its use as a *Mercury* booster. *Atlas* will be used as a booster for the *Vega* series of vehicles. *Vega,* due to be flight-tested next year, will provide propulsion for our heaviest and longest space probes until *Saturn* becomes available.

A more long-range program is the 1½-million-pound booster being developed for NASA by Rocketdyne. NASA is spending about $20 million in the current fiscal year for this single-chamber liquid rocket under a development program of four to six years. Another two or three years will be required to cluster that engine to produce a booster with six million pounds or more of thrust.

Herbert H. Rosen, NASA deputy director of public information, said this program could be accelerated somewhat by spending a little extra money. This would speed the program over the long run by providing insurance in the form of concurrent testing, additional machine-shop work and more computer time. Any attempt to push it more rapidly would run into such barriers as unavailability of engineering manpower, he added.

• **Erroneous estimates**—But the question of money runs headlong into another problem. Rosen said NASA officials made several errors on the low side last year in estimating their budget needs. He said the errors, plus the budget cuts made by Congress, have caused a slowdown in several NASA programs. "We could use more money," Rosen concluded.

To draw even and then ahead of the Soviets in propulsion, it is necessary to program a whole series of steps in rocket development. *Saturn,* whenever it is ready, is to be capable of putting 33,500 pounds into a 300-mile orbit or of delivering 2,700 pounds to a soft landing on the moon. Present ARPA plans to do this call for a *Titan* intercontinental missile booster as the second stage and a *Centaur* high-energy liquid-fuel engine as the third stage. The two **Aerojet** *Titan* engines use conventional liquid fuels to develop 360,000 pounds thrust. *Centaur,* under development for NASA by **Pratt & Whitney,** will be a liquid hydrogen-liquid oxygen engine with twin chambers each having 15,000 pounds of thrust.

Since the cluster of the 1½-million-pound single-chamber engines probably will not be available until 1968 or 1970, both ARPA and NASA officials are studying ideas for interim improvement of the *Saturn* system.

One of these ideas is a high-energy second stage. A. O. Tischler, chief of the NASA liquid fuel rocket engine program, says the Pratt & Whitney experience has demonstrated the possibility of scaling up to the size necessary for it to replace *Saturn* in the second stage.

• **Bigger payloads**—The advantage of a high-energy second stage, of course, is the increased payload. NASA calculations indicate that, in general, payload is increased by 50% whenever a conventional liquid-fuel stage is replaced by a high-energy hydrogen-burning stage.

Tischler said he believes development ought to begin now on a liquid hydrogen second stage. But again, funds are a major hurdle. He said all the major liquid-fuel rocket makers know the NASA requirements. "If we can find funds next spring, I think we may go ahead," Tischler added.

Tischler would make no estimate of the cost. "We shall approach this by competitive negotiation," he said.

Although Tischler said bids from all rocket companies would be considered if money becomes available, two would seem to be in a better position than the others. Pratt & Whitney has the benefit of its experience on the *Centaur* engine. Aerojet has made feasibility studies of such a stage under an Air Force contract.

An engineer on the staff of one rocket company made a "guesstimate" that developing high-energy second stage might cost from $50 to $100 million, depending on its size. Of course, only a small part of this would be spent in the first year.

Tischler said that if the development program takes three years, the engine can be ready for mockups in about two years.

- **Solid boosters?**—All of the foregoing concerns liquid-fueled engines. This does not mean that solid-fuel rocketmakers have given up the idea of building big boosters. Dr. Harold Ritchey, chief scientist for **Thiokol,** has put forth a proposal for a solid booster with 10 million pounds thrust. He said it would take about three years to develop.

Somewhat more conservative, D. F. Sprenger of Aerojet suggests that a solid motor could be developed with one million pounds of thrust. Both proposals were made at the **Avco**-Air Force Symposium on Advanced Propulsion Concepts in Boston earlier this month.

What are the Russians doing while we develop bigger boosters? As usual, they say very little. Published reports of Soviet propulsion research indicate they are investigating nuclear ramjets, ion acceleration and upper atmosphere recombination, as well as conventional nuclear rockets. They also report work on such exotic schemes as propulsion by radioactive isotopes, beta batteries and beamed microwave power.

Just as in this country, Soviet security rules seem to be relaxed a little for the more exotic systems of propulsion. We can only assume that they are working at top speed to improve their conventional, highly secret chemical systems.

NASA Orbits *Explorer VII*

WASHINGTON—The National Aeronautics and Space Administration was successful on its second attempt last week to launch a 91.5 pound payload which will study radiation and charged particles in the ionosphere.

An earlier attempt to put the top-like satellite into orbit ended in failure on July 16 when the *Juno II* booster was destroyed in flight by the range safety officer.

The vehicle, named *Explorer VII,* was sent into a 50-degree inclination, low-eliptical orbit so that it passes through the inner Van Allen belt. Its perigee is 346 miles and its apogee is 664 miles. The Army's *Juno II* rocket was the booster.

Explorer VII's payload is one of the most comprehensive and sophisticated to be sent into space by the United States thus far. (see M/R, April 27, page 20).

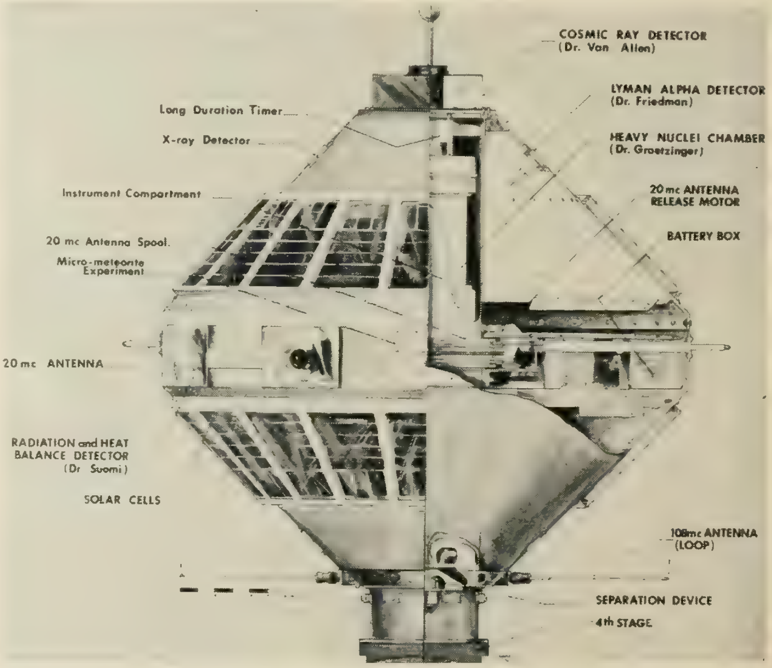
The top-like design aided fabrication of solar cells into the payload, and also helps obtain maximum gyro-stabilization with little or no precession. Release of the 20mc antenna spool retarded the vehicle's spin.

Instruments conducting major experiments include a cosmic ray detector, a lyman alpha ray detector, an X-ray detector, a heavy nuclei chamber, a radiation and heat balance experiment, and a micro-meteorite density detector.

The power is supplied by solar cells, charging nickel cadmium batteries. One of the experiments is to measure the performance of the solar cells which are not protected by micro-meteorite shields.

A clock will shut the payload's transmitter off after one year. The transmitter could conceivably be turned on again when and if NASA scientists require more information (See M/R, June 1, 1959).

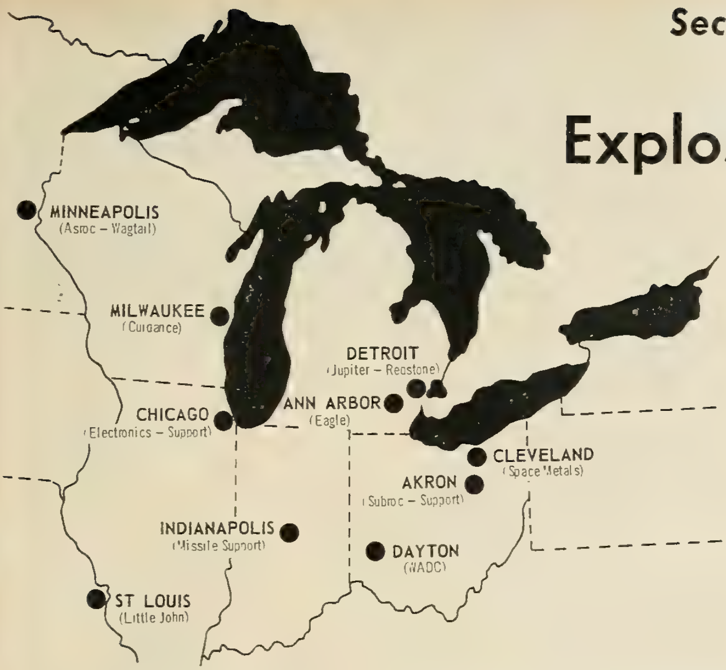
The satellite has no recorder, and ground stations record information only when the satellite passes over.



PARTIAL CUTAWAY drawing of the radiation satellite launched by a *Juno II* vehicle from the Atlantic Missile Range last week. Designed by the Goddard Space Flight Center, the payload will attempt to learn more about the Van Allen belts.

Second in a Series . . .

Explosive Growth in Great Lakes Area



M/R survey shows the multibillion-dollar missile business still expanding

by William E. Howard

MILWAUKEE—In the early Cold War days of 1948, 50 engineers and technicians on company orders pulled stakes from **AC Spark Plug's** home plant in Flint, Mich., and set up shop here in a government-owned factory. Their mission was to build SAC bomber navigation and sighting systems utilizing gyros.

By 1955, the new division was manufacturing a stellar inertial bombing system (SIBS) based on principles developed by MIT's guidance wizard, Dr. Charles S. Draper. SIBS proved to be the forerunner of an all-inertial guidance system, AChiever, which the company began to develop a year later for the Air Force *Thor* IRBM. It was also the start of a vast expansion in plant and personnel.

Today, AC's Electronic Division holds contracts totalling more than $300 million. Along its assembly lines move the highly precise guidance units for not only *Thor,* but the Air Force *Titan* ICBM and the Tactical Air Command's 650-mile *Mace.* The division has more than 7000 employees and farms out work to 4000 subcontractors and suppliers employing thousands more.

The division this week is in the process of adding close to a quarter million square feet of floor space to its modern plant which already covers 500,000 square feet in suburban Oak Creek. All of this activity, in just eleven years, has made AC the largest missile contractor in Wisconsin and the main producer of defense products in the huge **General Motors** industrial empire.

The remarkable expansion of AC is but one illustration of the enormous impact of missile/space demands upon industry in dozens of communities in states bordering the Great Lakes. An M/R survey shows, in addition to Wisconsin, an explosive growth of missile electronics in Minnesota; prime systems and sub-assemblies in Michigan, Ohio and Indiana; and missile support in Illinois.

• **Ten missile primes**—Eight prime missile system contracts are distributed throughout five of the six states in the region. (Wisconsin is the exception.) These include the Navy's *Asroc, Eagle, Subroc,* and *Weapon A,* which is also called *Able;* the Air Force's *Jupiter* and *Wagtail;* and the Army's *Redstone* and *Davy Crockett.*

If the region is stretched a mite to embrace St. Louis, across the Illinois border, then the total will be 10, counting the Army's *Little John* made by **Emerson Electric,** and the Air Force *Quail* by **McDonnell Aircraft Corp.**

Contracts for these 10 birds total well over $1 billion. Additional millions are being spent by the military and civilian agencies on components and subsystems for dozens of other programs. Moreover, the Great Lakes area is deeply involved in government-funded advanced research and development of metals and materials for missiles and space vehicles.

For most of the states, the outlook is for a continued steady growth of the missile industry. One possible exception is Michigan, which has suffered defense procurement reverses (M/R Oct. 12, p. 18) and is now hoping for new contracts to offset the washout of *Redstone* and *Jupiter,* both primed by **Chrysler Corp.** The state's remaining prime is **Bendix Aviation,** Ann Arbor, for the Navy's *Eagle* air-to-air missile.

• **Astrionic rivals**—Wisconsin, famed for its beer, Braves and dairy products, and Minnesota—better known for its mineral deposits and the wild beauty of its hundreds of lakes—today are running neck and neck for regional leadership in the field of astrionics. The race boils down pretty much to the two giants, AC Spark Plug and the **Minneapolis-Honeywell Regulator Co.,** Minneapolis. But there are scores of other companies in the field.

AC's missile guidance contracts and other work give the electronic division annual sales estimated at $100 million a year. M-H's military electronics volume is estimated at around $90 million—about 25% of the company's gross yearly income.

M-H is prime for the surface-to-underwater *Asroc,* an anti-submarine weapon and also the AF's *Wagtail,* a low-level air-to-ground missile now in R&D. The company also produces gyros for *Sergeant* and fuzes for *Sidewinder.* In the space field it makes the guidance for NASA's *Scout* and last week the Aeronautical Division delivered a seven-ton space cabin simulator to the AF School of Aviation

ANTENNA farm for microwave relay system used by Harvard University was built by Raytheon at Havana, Ill., southwest of Peoria.

Medicine, Brooks AFB, Tex., for the training of astronauts.

Minnesota may hold the edge in total volume. The State Department of Business Development says there are more than 100 firms engaged in electronic and electrical work, generating aggregate sales of $500 million annually. They include an **International Business Machines** plant at Hopkins, with a $30-million volume; **Remington Rand's** Univac division at St. Paul, doing an estimated $90 million; **General Mills** Mechanical Division, Minneapolis, with 2000 employees and sales exceeding $25 million; and **Minnesota Mining and Mfg. Co.'s** Electrical Products Division—$65 million.

Apart from large companies, in the Minneapolis-St. Paul area there are 47 small firms employing 3600 persons and grossing $50.5 million annually in sales. Many of these were started within the past five years. The latest one—**General Magnetics**—was founded this year.

Minneapolis also boasts an investment company—**Midwest Technical Development Corp.**—which specializes in the financing of scientifically-oriented companies.

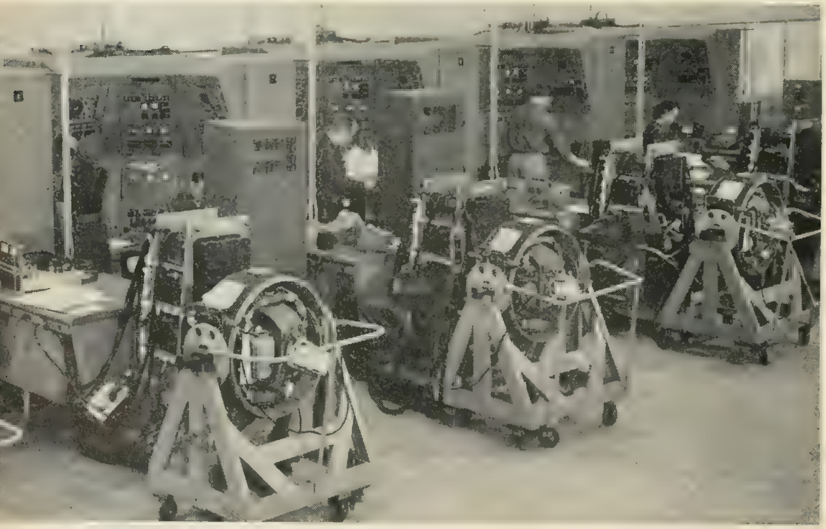
• **Wisconsin development**—Contributing to the growth in electronics in Wisconsin are the **John Oster Mfg. Co.,** Racine, which produces components for several missiles; **George W. Borg Corp.,** Janesville, indicating devices; **Milwaukee Transformer Co.; Milwaukee Electronics Co.; Gibbs Mfg. and Research Co.,** Janesville; **Heale Mfg. Co., Waukesha;** and the **Trionics Corp.,** Madison.

General Electric Co.'s X-Ray Division, Milwaukee, is a maker of airborne cameras, which may have missile/space applications.

The state also has moved swiftly ahead in metallurgy and metal fabrication. Two outstanding examples are the **Ladish Co.,** Cudahy, a major missile component supplier and leader in drop forging, and the **A. O. Smith Co.** of Milwaukee. Ladish produces drop forged forward domes, nozzles and seamless rolled ring body cylinders. A. O. Smith has developed a roll and weld fabricating process for rocket chambers.

In addition to several manufacturers of specialized machinery used by the missile industry, there are such companies as **FWD Auto** and **Oshkosh Truck** supplying missile support vehicles. **Marathon Electric Mfg. Corp.,** Wausau, makes generators for *Nike* sites.

The AF Milwaukee Air Procurement District, biggest military buyer in the area, reports that as of June it had $395 million outstanding in contracts—mostly for missiles. Out of every $100 it spends in Wisconsin and Minnesota, the District says $77 goes for electronic end-items.



THESE CONSOLES at AC Spark Plug's Milwaukee plant put a complicated AChiever guidance system through simulated flight tests before delivery to missile bases.

• **Illinois has** *Davy Crockett*—Illinois, which has suffered a sharp cutback in defense production since the Korean War, so far has been able to come up with only one prime missile contract. This is the Army's bazooka-like *Davy Crockett*—an in-house R&D project of the Rock Island arsenal.

However, many companies are big subcontractors on other projects and others are making important contributions in the way of materials and support items. Most of the activity is concentrated in the northern part of the state.

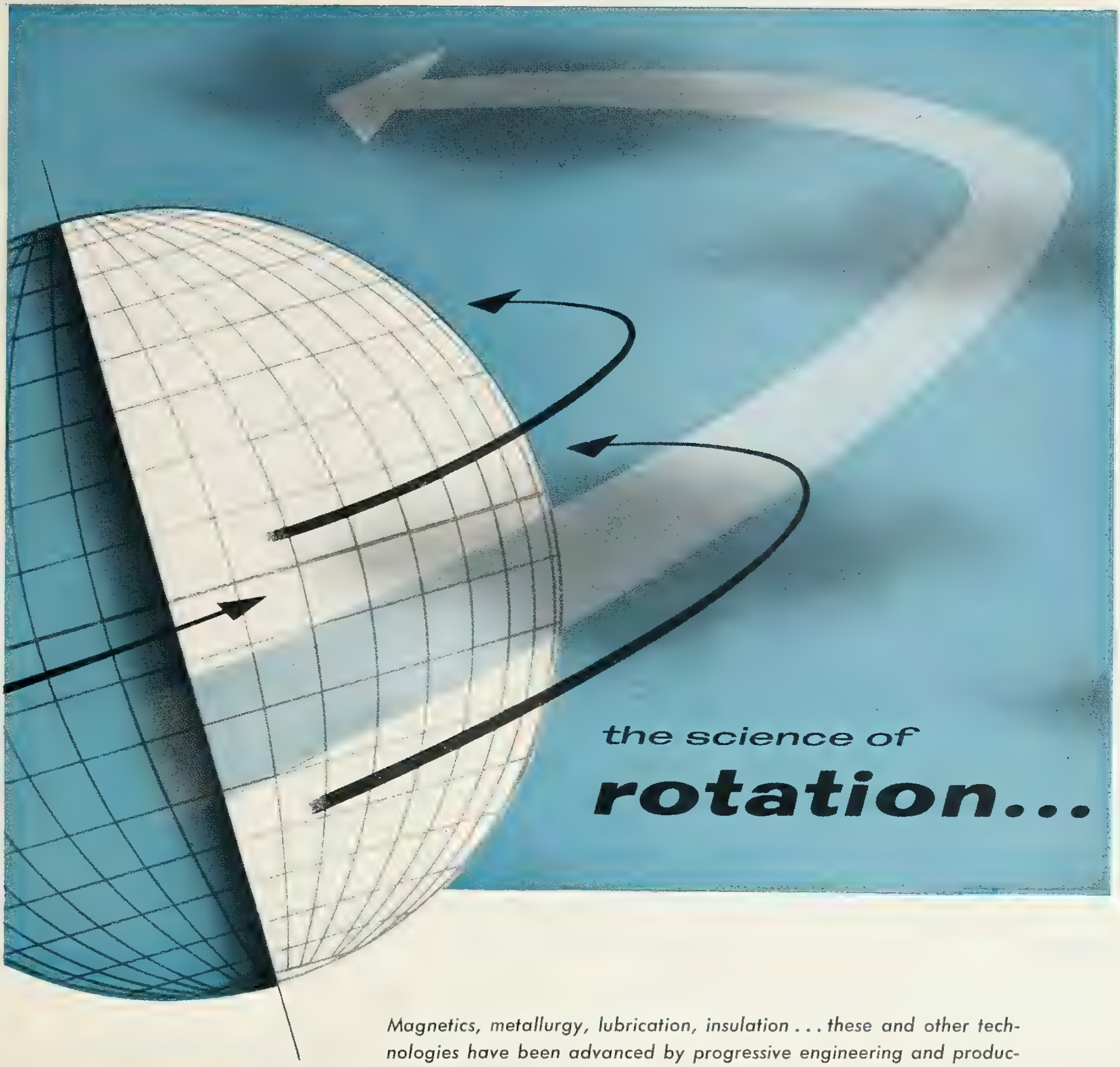
Around Chicago, **Stewart Warner Corp.** is making heat exchangers for the AF *Hound Dog* air-launched missile; **General Sintering Corp.** is fuzing the AF air-to-air *Falcon*; **Continental Can** and **Joy Mfg. Co.** are making, respectively, target radar mounts and compressors for *Nike*; and the **Elgin National Watch Co.** is fuzing *Sidewinder*. At La Salle, **General Time Corp.'s** Westclox Division is providing the safety and arming device for *Sidewinder* and is also fuzing the Navy's *Zuni*. And in Rockford, **Sundstrand Aviation** is making hydraulic meters for *Hound Dog*.

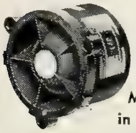
Electronics manufacturing has quickened around the Windy City, too. One of the major missile suppliers is **Cook Electric Co.,** which currently is providing instrument calibration standards facilities and services for R&D contractors at Vandenberg AFB, Calif.

Physical evidence that the Space Age has caught up with the land of Lincoln can be found at Havana—southwest of Peoria—where a huge antenna farm has been built. This is a microwave relay system being used by the Harvard College Observatory to study meteor particles and their effect on radio transmission.

• **Flipper for** *Falcon*—Two Navy missile systems are lending impetus to Indiana's industry. The Mishawaka Division of Bendix Aviation Corp. is prime for assembly and test of the surface-to-air *Talos* and also makes the weapons' propulsion subassemblies. At

(Continued on page 44)





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ATLAS ICBM
MERCURY
VEGA
CENTAUR

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BULLPUP **missiles, mounted on FJ-4B, are irradiated by APS-20E radar on search aircraft in the rear.**

HERO Explores R-F Radiation Hazards

Unpublicized Navy project seeks to identify electromagnetic dangers to missiles and control them; one goal is to cut radio receptivity

by Hal Gettings

DAHLGREN, VA.—A relatively modest program being conducted by the Naval Weapons Laboratory (formerly the Naval Proving Ground) may have much more important implications for the missile business than its limited budget indicates. Designated *HERO* (for Hazards of Electromagnetic Radiation to Ordnance), it is aimed at determining just what potential dangers exist and what can be done about them.

Ordnance people have become increasingly aware that the trend toward more and higher-powered electronics equipment in the vicinity of explosive ordnance constitutes a hazard of unknown extent. No organized research was started, however, until less than two years ago. It is to the Navy's credit that the problem came under scrutiny before a possible catastrophic explosion did take place.

Practically nothing has been published on the project. Until about six months ago, even the definition of *HERO* was classified. Today, although most of the findings and results of the work must still be kept under security wraps, the problem can be examined in some detail. And the Navy feels that awareness of the work in progress may smoke out ideas from other engineers living close to the situation.

Fiscal 1959 and 1960 budgets for the Navy project amount to approximately $1 million per year. About one-third of this is spent in-house by the Weapons Laboratory. The balance is spread among several other agencies and research institutes shown in the organization chart.

This is a problem that concerns the entire Department of Defense. Although work is mostly concentrated in the Navy's RadHaz (Radiation Hazards) program, other branches of the armed forces are also supporting efforts in this area. Bureau of Aeronautics is spending approximately $100,000 per year on similar work. The Army has no programmed research but maintains a facility at Edgewood Arsenal to check on any reported damages to personnel or equipment. Air Force work is confined mostly to radiation hazards as affecting personnel.

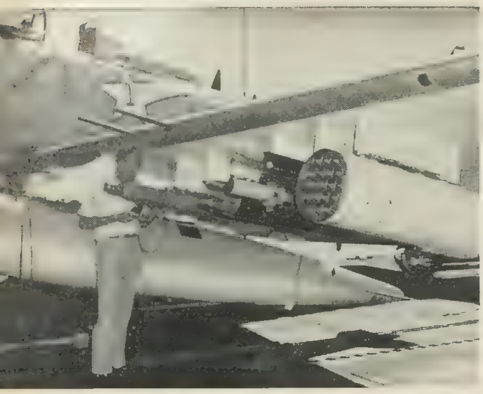
- **The problem**—Before any problem can be solved it must be defined; the first function of the *HERO* investigation is to explore the magnitude of the problem and its relation to handling, storing, and delivering missiles. This leads to the second function: learning what to do about it.

The surprises which can be produced by electromagnetic energy are indicated by some fairly familiar phenomena. More than one photographer has had flashbulbs suddenly pop in a radar-equipped airplane or near ground-based radar. Stories are legion of the old lady's bridgework that unexpectedly acted like a crystal radio and tuned in the eleven o'clock news. There have even been reports of a kitchen range making like a hi-fi set.

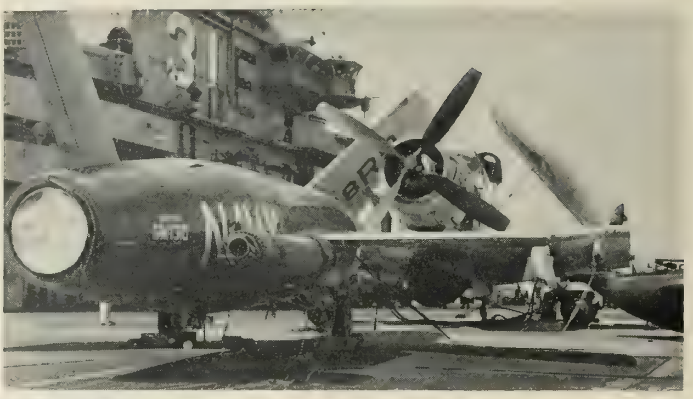
Radio-frequency energy—at microvolt levels—literally surrounds us. All we need to do is tune it in on a receiver and we can hear sound or see a picture carried by this energy. In the vicinity of missile bases, aircraft carriers and other ships, and defense installations in general, a high concentration of radars, communication transmitters, and similar electromagnetic generators raises the amount of this energy to a potentially dangerous level.

In the missile business, the problem is compounded by two facts: modern weapons require high-powered radar; they also require electroexplosive devices in the propellant, fuzing and arming systems.

Potential hazards exist almost everywhere. Warheads and propellant systems may be exposed to high r-f energy levels in storage, use, and transportation. Missile-carrying planes fly through radio ranges and radar beams. Their own radar and radio equipment *interim safety instructions are early result . . .*



SELECTION OF aircraft rockets are mounted under the wing of an AD-6 for exposure to high-level r-f energy.



ENERGY FROM aircraft search radar (in rear) is beamed at *Regulus 1* missile with booster during the RadHaz program directed and funded by the Navy's Bureau of Ships.

is, of course, always a present threat. Control, guidance, and tracking equipment all direct energy directly at the missile. Communications equipment is always in the vicinity.

• **Techniques**—The problem is extremely complex because of the infinite number of variables involved. Work at present, therefore, is concerned largely with setting guidelines for further investigation.

HERO's approach is to look at each weapon as a receiver which is or may be tuned to a particular frequency of electromagnetic radiation. Every circuit element is considered as a potential tuned circuit capable of absorbing r-f energy at certain frequencies.

The Navy will not reveal exact details of techniques used in this work. In general, however, field energy intensities must be measured in the vicinity of ordnance and the intensity related to "susceptibility."

Some tests involve beaming r-f signals from a variety of sources directly at the missile. In most cases, dummy warheads and propellant loads are installed. In others, the complete weapon is tested. These go/no-go tests show which propellant igniter or warhead fuze can be fired by the radiation. Failure to fire, however, indicates only that the particular item *may* be safe.

Other tests use instrumentation installed in the circuitry to measure levels received and determine susceptibility. These methods are complicated by the fact that missiles must be tested in their usual environments—in the launcher, storage area, or transportation package. Tests must therefore be conducted aboard ship or wherever else the missile may possibly be used or handled. Further, in some instances the addition of instrumentation can change circuit characteristics and cause a completely false result.

• **Facilities**—Since most of the *HERO* project work is concerned with aircraft air-to-air and ship surface-to-air missiles, much of the actual testing is done aboard carriers and missile ships. In addition, simulated ship installations are being set up on shore. One such facility has been constructed at NOTS, China Lake, Calif. Another is being built at Dahlgren. This will include a 15-foot turntable in a simulated carrier deck for orientation of weapons with respect to transmitting equipment.

A selection of high-powered radio transmitters—some mounted in mobile vans—covers most of the frequency spectrum. Except for more or less conventional measuring instruments, the balance of project equipment consists of A4DB missile-carrying fighter aircraft. Other equipment is being added as requirements develop.

• **Results**—About 10 major test programs have been conducted by *HERO* to date. Here, again, data on results are kept under tight security. But several important basic facts have been brought to light:

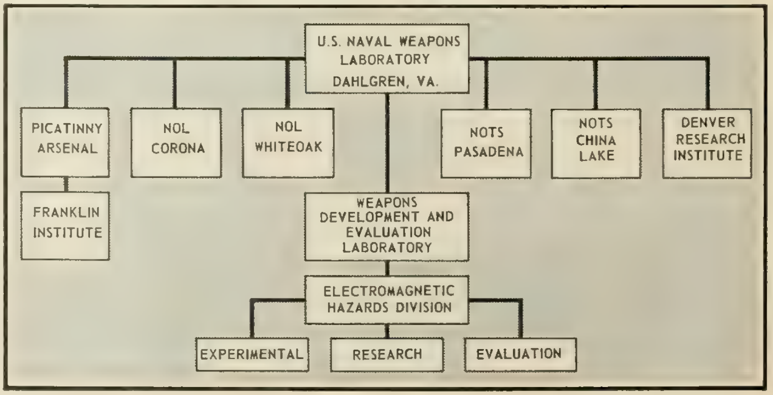
• A hazard definitely exists where electroexplosive ordnance is subject to electromagnetic radiation. The magnitude of this hazard is not known. It can be determined only with further work and better instrumentation.

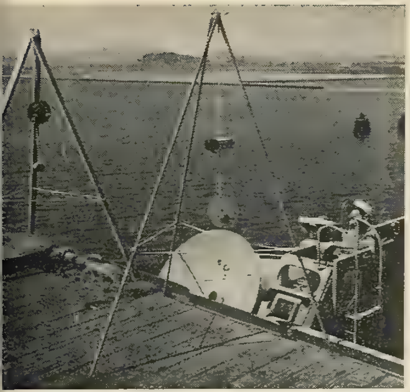
• Certain ordnance is susceptible under certain conditions.

• The hazard can be reduced or eliminated in several ways.

As a result of their findings, *HERO* engineers have provided the fleet with interim safety instructions on handling, storage, and operation of ordnance in proximity to r-f sources. They have researched several ideas on "r-f proofing" ordnance. Some of these have proved successful over specific frequency ranges but none over the entire spectrum.

Organization of Project HERO


U.S. NAVAL WEAPONS LABORATORY DAHLGREN, VA.
PICATINNY ARSENAL
NOL CORONA
NOL WHITEOAK
NOTS PASADENA
NOTS CHINA LAKE
DENVER RESEARCH INSTITUTE
FRANKLIN INSTITUTE
WEAPONS DEVELOPMENT AND EVALUATION LABORATORY
ELECTROMAGNETIC HAZARDS DIVISION
EXPERIMENTAL
RESEARCH
EVALUATION



TESTS INCLUDE exposure of demolition firing device and parachute control to transmitted power.

Recommendations and instructions based on team findings show three possible approaches for those concerned with the threat:

1) How to live with an existing and unchangeable situation;

2) How to modify to alleviate the problem;

3) How to design around the problem.

Future work is aimed at making a major advance in reducing the radio receptivity of the missile—from tens to hundreds of db down. Thus they will be safe under almost any level of electromagnetic intensity. To date, the Navy has had no known fatal accidents from electromagnetic radiation sources—the mission of *HERO* is to keep that record clean.

It is fairly certain that facts learned from this investigation would be useful in developing the often-mentioned "death ray"—the concentration of electromagnetic energy to knock out enemy weapons and personnel. But project engineers deny that they are interested in this aspect; neither, apparently, do they foresee the techniques used in countermeasures work.

Project *HERO* is a Bureau of Ordnance-funded program, but closely allied with the broader RadHaz program funded and directed by Bureau of Ships. BuShips, under the direction of J. J. Fisher, has responsibility for coordinating the various projects concerning r-f hazards to personnel, fuels, and ordnance. BuOrd chain of command for *HERO* includes C. A. Johnstone, chief engineer; C. B. Brown, assistant for electronics; C. M. Cormack, special assistant for radiation hazards; J. W. Payne, head of Electromagnetic Hazards Division; and LCdr. C. F. Fadeley, assistant.

Meteor Bursts Used in Radio

BOULDER, COLO.—Intermittent meteor-burst communications can be used competitively with other long-distance radio systems according to a recent report by the National Bureau of Standards.

A three-year test program has been conducted by NBS Boulder Laboratories to determine the feasibility of a long-distance VHF communication system employing signal reflections from ionized meteor trails.

Sponsored by the Air Force Cambridge Research Center, the program has resulted in a two-way radio teleprinter system having a transmitting speed of up to 4800 words minute. This is 80 times that of regular teleprinter speeds. In addition, the meteor-burst mode appears to be relatively free of the ionospheric disturbances which often degrade HF communication systems.

Preliminary tests were performed over a 390-mile path from Sterling, Va., to Walpole, Mass. An 800-mile path between Kilbourne, Ill., and Erie, Colo., was used for most of the test program.

Because of the nature of meteor trails, a new approach to message handling and control was necessary to successfully use the phenomenon. Most of the millions of small meteors entering the earth's atmosphere are vaporized by the intense heat developed by atmospheric friction in the lower ionosphere. This creates a trail of electrons and, thus, ionized atoms extending approximately 15 miles behind the remains of the meteor.

This ionized trail reflects radio waves and causes short-time signal enhancement.

Since the trail is short-lived, a system making use of its reflective characteristic must operate intermittently at very high speed, and must be operated automatically. Message storage is mandatory while awaiting a usable meteor trail.

By its nature, this type of system is almost totally safe from jamming.

The system employs two 5-element Yagi antennas. It was operated at a frequency of 49 mc/s with a 2-kw power output. Antenna design is based on meteoric ionization at an elevation of 110 kilometers.

The system is not without defects, and these will require more study before they can be minimized. Two coexistent meteor trails occur frequently enough to be a serious error source. Electrical storms and precipitation static also can be a serious problem. Manmade radio interference causes degradation but NBS feels this can be minimized through improved equipment design.

NBS Certifies Needed Critical Measurements

The National Bureau of Standards, in a development necessary in the production of critical components for space vehicles and systems, has certified the accuracy of its length measurements made on two commercial gage blocks to better than one part in 5,000,000.

The measurements announced by the U.S. Department of Commerce were made on a 16" and an 18" gage block. Each block was converted into a line standard by wringing a graduated gage block to each end. They were then compared with the working standards of the U.S. bars with carefully engraved lines marking the standard distances.

The blocks were then measured in terms of wavelengths of light. The results obtained by the two methods agreed to the nearest millionth of an inch or better for both gage blocks. This not only "proves" the accuracy which can be obtained in gage-block measurements, but also serves to verify the accuracy of the wavelength of various light waves as expressed in terms of the international meter bar. The NBS measurements also agreed to two microinches with independent measurements made by the National Physical Laboratory (England) on the same blocks.

Solar Flares May Cause Much Radio Disturbance

PONTIAC, MICH.—Solar flares may cause more interference with radio transmissions than do sun spots, long blamed for such difficulties.

This is one of the tentative conclusions reached as a result of new research into the daily activity of the sun, conducted by University of Michigan astronomers here under a grant by the National Science Foundation.

The study is part of a long-term worldwide effort to relate solar phenomena to various earthly effects such as radio disturbance. The information collected is sent daily to the Bureau of Standards, which predicts interference patterns and affected frequencies up to a week in advance.

Solid Fuels are simple—

but!

Whether the rocket power be for the Army's Sergeant, the Air Force's Minuteman or tomorrow's 50,000,000 lb. thrust motor it begins with globs and strands of fuel held in the asbestos-gloved hands of the research chemists.

For more than ten years the research scientists in THIOKOL's Rocket and Chemical Divisions have been continuously engaged in rapidly expanding programs of propellant development.

In these endeavors one fact is common: new propellants are cast into rocket motors only after many thousands of hours have gone into research and testing. For every successful propellant formula there are many, many frustrating failures. This is the way of research. Success, even though it comes slowly, is the reward.

Fortunately, success has come to THIOKOL research scientists in abundance and with regularity.

The variety of career opportunities at THIOKOL is large and expanding, including:

Propellant analysis and formulation • Polymer research • Fluorine and metal hydrides synthesis • Shock wave phenomena • Combustion processes • High vacuum techniques • Fast reaction kinetics • Servo system and electro mechanical design • Instrumentation • Ion and plasma propulsion • Magnetohydrodynamics • Thermodynamics • Solid state physics.

There may be a place for you on the team, working on THIOKOL—developed-and-built rocket powerplants used in the Falcon, Sergeant, Matador, Nike Hercules, Lacrosse, X-17, Minuteman, Pershing, Nike Zeus, Sparrow III, X-15, Bomarc, Little Joe, and Bullpup.

For further information contact Personnel Director of any of these plants: Huntsville, Ala.; Elkton, Md.; Moss Point, Miss.; Brigham City, Utah; Trenton, N. J.; Bristol, Pa.; Denville, N. J.; Marshall, Texas.

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at RAS-IAS meeting . . .

Canadians Say Transmitter Withstands Half-million G's

by an M/R correspondent

NEW YORK—Development of miniaturized instrument packages which have withstood g-forces far in excess of a full impact on the moon was reported by the Canadian Armament Research and Development Establishment at the 7th Anglo-American Conference here Oct. 5-7.

According to the report of Dr. G. V. Bull, superintendent of the CARDE Aero/Physics Wing, at the Royal Aeronautical Society-Institute of the Aeronautical Sciences Conference:

"A transmitter was found to be in good working order after taking half a million g's upon slamming into a two-inch aluminum pipe."

The transmitter consisted of nine electronic components assembled and potted into epoxy resins. The basic unit was then potted into araldite reinforced with fiberglass cloth and machined to desired shape. The complete circuit fit a cylinder 0.5-inch in diameter and 1.5 inches long, which was placed in a projectile 1 inch in diameter and 3.75 inches long and launched with a velocity of 6000 ft./sec. from a 3.125 smooth-bore gas gun.

The transmitter batteries were broken off on impact, but when batteries were added in the laboratory, the transmitter was still operating. It was powered by 5-RM 400 R Mallory-cells, which delivered 33 milliwatts and were capable of operation for 16 hours.

"Such packages could easily withstand hard impact on the moon," said Dr. Bull, who estimated that a payload might be subjected to 100,000 g's in crashing on the moon.

• **Solar flares and satellites**—E. C. Cornford, head of the guided weapons department, Royal Aircraft Establishment, Farnborough, disclosed that a team of three British scientists has compiled new data confirming a relationship between solar activity and satellite orbit decay.

Cornford, working with D. G. King-Hele and R. H. Marson, all of the RAE, studied kinetheodolite data on 15 satellite orbits, collected in RAE sightings and from other European observers. Results from the United States also were studied. The material was presented in a paper entitled "Recent studies of Satellite Orbits."

Plots of sightings, particularly of *Sputnik II* and *Vanguard I*, showed a 28-day oscillation in the rate of orbit-time change. The 28-day period between peak values in orbit-time change correlated closely with solar flare activity. Cornford described correlation between the flares and *Vanguard I's* plot as "nearly perfect." This was also supported by data from *Vanguard II* sightings, now under study. The British scientists also found close correlation between minimum orbit period change and minimum solar activity.

The authors concluded that solar activity strongly influences the air density in the upper atmosphere.

Cornford also presented his teams calculated values for air density, ranging from 4.1×10^{-11} lbs/ft^2 at an altitude of 100 nautical miles, to 4.0×10^{-13} at an altitude of 220 n.m.

New values for various J_n orbit perturbation factors were presented. Using these new values, they determined that the difference in the earth's equatorial and polar diameters is 500 feet less than that computed before satellite sightings were available.

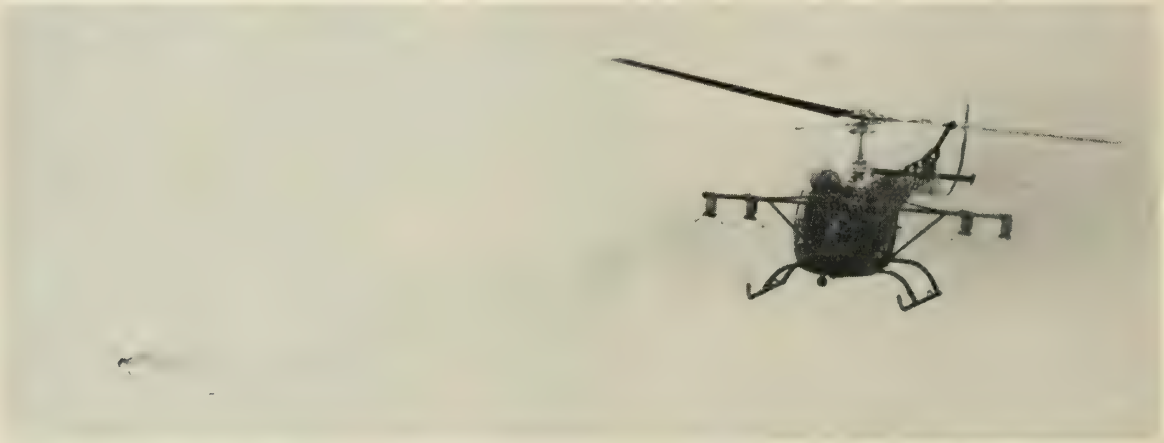
• **Ablation for nozzles?**—Dr. Lester Lees, professor of Aeronautics, Guggenheim Aeronautical Laboratory, California Institute of Technology, in discussing "Ablation in Hypersonic Flows," disclosed that ablation is under study for special uses in rocket nozzles. He declined to elaborate.

Dr. Lees said he did not think it would be long before ablation applications would be disclosed in "certain internal combustion applications in rocketry."

He compared ablative shields in re-entry problems to meteors entering the earth's atmosphere. The enormous kinetic energy of the meteor, at a relative entry speed of 44 miles per second, with millions of BTU's per pound, causes it to burn. Man, through use of ablative shields, seeks to bring this process under control. At present, man's efforts are with re-entry velocities of only about 40,000 feet per second, and heat of about 30,000 BTU per pound. He described numerous theoretical investigations which have contributed to understanding of the fluid mechanics of ablation.

French *SS-10, SS-11* Stake Out Possible Big Role with Army Air

Growing Army airpower may use both birds on fast helicopters and fixed-wing aircraft; new R&D SS-12 may also join the arsenal



WIRE-GUIDED *SS-10* **(far left) flashes from Bell H-13. Explosive bolts remove launcher and wires after firing.**

by James Baar

WASHINGTON—The **Nord** *SS-10* and *SS-11* are coming into their own as principal weapons of the Army's growing airpower.

The two solid-propelled missiles—originally purchased as light surface-to-surface anti-tank weapons—have been found particularly effective when launched from Army reconnaissance helicopters and fixed-wing aircraft.

The Army no longer sees the conventional warhead-packing French missiles as primarily anti-tank threats, but rather as weapons proven effective against a wide variety of targets.

It has found that helicopters loaded with *SS-10's* and light fixed-wing planes loaded with *SS-11's* will be capable of providing powerful close air support to infantry and armored columns.

Moreover, this firepower may be augmented by the new, secret Nord *SS-12* which is rapidly approaching the operational stage.

The solid-propelled *SS-12* is about twice the size of the *SS-11*, has greater range and may eventually be able to carry a sub-kiloton nuclear warhead. Unlike the *SS-10* and *SS-11*, the *SS-12* is not wire-guided.

The successful marriage of the *SS-10* and *SS-11* to U.S. Army aircraft is expected to lead to new increases in the Army's already-large purchases of them.

The Army purchases of either the *SS-10* or *SS-11* also is expected to be increased greatly with the completion of evaluation studies of the *SS-11* next month or in December. The Army will decide at that time whether to switch to the *SS-11* for use on tanks, jeeps and trucks.

The decision will be reflected in the FY 1961 budget. No money for the *SS-10* or *SS-11* was included in the FY 1960 budget because the Army wanted to wait until the evaluation of the more powerful *SS-11* was completed.

The Army in the last year signed contracts for some $12 million for the two missiles, and deliveries are still in progress. No official figures have been released on how many of the missiles have been purchased. However, a good estimate is more than 10,000 *SS-10's* for deployment to troops in the continental United States and overseas.

To date Nord has sold a total of about 28,000 *SS-10's* and *SS-11's* to 11 countries including France and the United States. Other buyers are West Germany, Italy, Sweden, Denmark, Norway, Israel, Canada, Great Britain, and Switzerland. The missiles have virtually become standard NATO equipment except in Great Britain.

Both missile's popularity is based on a number of attractive features that include:

- Weight and size—The *SS-10* weighs only 33 pounds; the *SS-11* only 63. Both are stubby and compact. These features make them extremely mobile.
- Cost—Both missiles are relatively cheap. The *SS-10* costs about $750. The *SS-11* costs about $1150.
- Accuracy—Both are highly accurate. They are guided by two thin wires that are played out of the mis-

sile as it flies. The 1600-yard-range *SS-10* can hit a six-by-two foot target.

U.S. purchases of *SS-10's* already have been delivered to the 7th Army in West Germany, the 8th Army in South Korea and STRAC divisions in the United States. Meantime, both the *SS-10* and *SS-11* are undergoing evaluation—particularly for their use on Army aircraft.

So far, the *SS-10* appears more suited for use on helicopters; the *SS-11* on fixed-wing planes because of its 3800-mile range and greater speed.

Loaded with *SS-10's*, the helicopter becomes a formidable weapon or war.

It can hover in woods or behind hills, rise long enough to fire its missiles and disappear again. It can fly at tree-top level. It can move rapidly with advancing infantry, knocking out enemy emplacements and tanks. It can move with tank columns, providing continuous close air support.

The **Bell** H-13 Sioux helicopter can carry four *SS-10's*. The helicopter carries two men—a pilot and one man to fire the missiles. It operates at about 65 miles an hour and has a 200-mile range.

The new Bell HU-1A can carry four to six *SS-10's* plus an extra supply in its five-passenger cabin. It has a speed of more than 100 miles an hour and a 230-mile range.

Arming helicopters with missiles is a departure from the Army's previous use of aircraft since the creation of the Air Force as a separate service. But it has had its precedents.

The Army for the most part has been using its some 6000 helicopters and fixed-wing planes for such activities as observation, short-hop troop movement, reconnaissance, communications and casualty evacuation.

However, Army helicopters in the past have been armed with 4.5-inch high velocity rockets, 50-calibre machine guns and 20-millimeter cannon. A **Sikorsky** H-34 Choctaw helicopter has been armed with all three, giving it as much firepower as one volley from a World War II artillery battalion.

The French were the first to deploy the *SS-10* on aircraft. French helicopters have fired them with considerable success in the Algerian insurrection. Army tests have been based on the French experience.

The possibility of any rapid buildup of Army missile helicopter squadrons depends on two factors: The tight budget problem and the division of missions between the Army and Air Force Tactical Air Command.

The Air Force, which must spend its dollars first on strategic airpower rather than tactical aircraft, may be willing to look the other way rather than fight an Army buildup of close support air forces.

But money may prove to be the big stumbling block.

The Army FY 1960 budget has only $5.8 million for 100 H-13's and $25.2 million for 90 HU-1's. The FY 1961 budget probably won't provide for any increase in buildup if as much.

Mobile Fire Control Unit in Service at Test Track

HOLLOMAN AFB, N. M.—A "traveling blockhouse" is being operated here on a 35,000-foot captive missile test track.

The 1.5-ton mobile fire control unit—designed and constructed by Captain Burden Brentnall, fire control officer, and Earl McDonald, chief maintenance foreman—will eliminate the heavy equipment hauling of concrete pillboxes previously necessary at the track.

Fabricated of armor plate with plexiglass blastproof windows, the unit contains its own generating and air conditioning systems, two-way radio, multi-cable for track wiring and a base-connected telephone.

The unit will save an estimated $35,000 annually in equipment costs, the Air Force said.

Canadians May Free-fire *CHARM* in Early Summer

TORONTO—The Canadian Rocket Society has hopes of running full-scale free firing tests of Project *CHARM*, its low-budget, high-altitude research rocket, by sometime early next summer.

A working model of the "Canadian High-Altitude Research Missile" system, on display at the I.R.E. Canadian convention recently, included encoder, 240 mcs. radio link, decoder, automatic data reducer, high-speed recorder and a just-finished 12-foot launcher.

The Society says it has been conducting a series of static tests for the past year and hopes during the next winter to produce the final grain configuration for the first stage. It also reports the development of a modified GALCIT fuel and "promising results" with radial burning designs.

A method of forming the grain was developed which divides it into six separate "cassettes," each completely enclosed in its own inhibitor except for the internal star section burning surface. The cassettes are locked in place in the motor casing. Stress problems associated with a large single grain were said to be largely overcome.

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weighs only 1.8 lbs.

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#1 Pole 45 BBM contacts, 90% nominal duty cycle
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Phasing — Pole #2 lags Pole #1 by 50 microseconds minimum

Standards: Military MIL-E-5272, MIL-I-6181B

Temperature	Operating, —20°F to +185°F
Altitude	0 to 100,000 feet
Vibration	.05 g^2 per cycle per second; 20-2000 cps random; 5 minutes each on 3 axes
Shock	100g, 10 millisecs, sawtooth, six directions
Acceleration	45g for 2 seconds in six directions
Service Free Life	100 hours guaranteed; 500 hours expected
Insulation Resistance	100 megohms at 300 volts d.c.
Hi Potential Test	500 volts, 60 cycle a.c., 1 min. each lead to ground

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Complete specifications and drawings available on Technical Bulletin No. 500602

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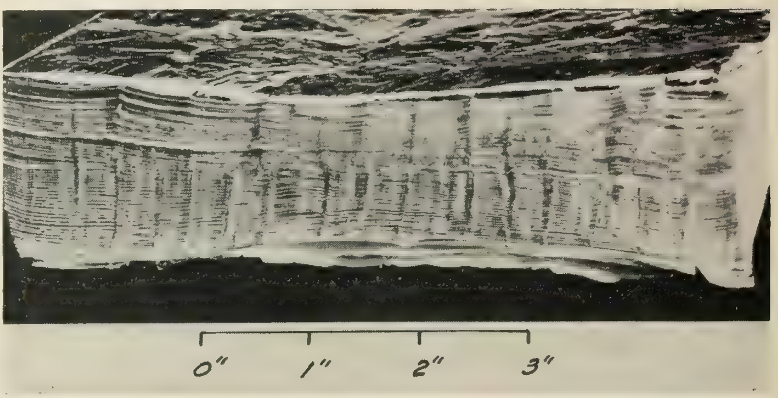
Linde Offers 'Super' Insulation

Here's a report on a new advance in the search for better cryogenic insulating materials, together with a guide to practical comparison of systems

by John F. Judge



SAMPLE OF Linde's SI-4 laminated "super insulation," which greatly eases handling of liquid hydrogen. The company is working on a similar type to cost half as much.

WASHINGTON—**The Linde Company** has developed a laminated "super insulation" which makes liquid hydrogen as easy to handle as LOX.

The material consists of 40 to 80 layers per inch of sub-micron glass-fiber paper and aluminum foil under absolute pressure, in insulating space, of 1.0 microns of mercury or less.

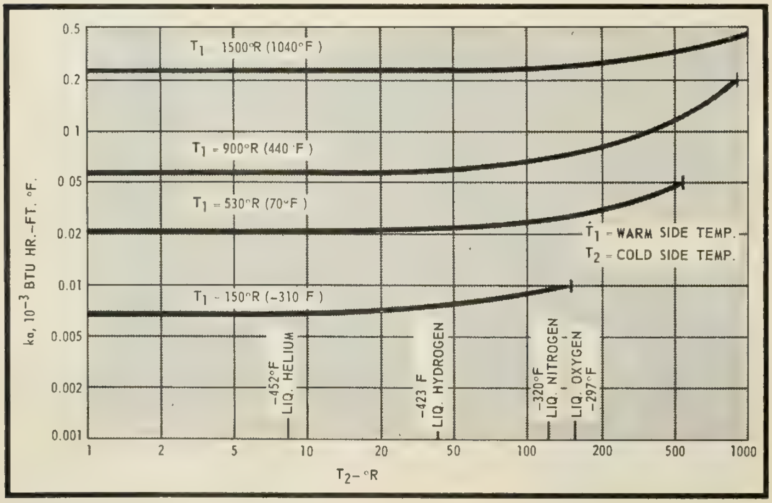
When incorporated into the popular 26,000-gallon storage tank, the new insulation, designated SI-4, makes it possible to store liquid hydrogen for a year with less than 10% content loss.

The development is the latest advance in the search for better cryogenic insulation to meet the changing demands of the missile/space industry.

SI-4 has a thermal conductivity of 0.025 x 10^{-3} BTU/hr-ft-F° (commonly known as the k factor) between 80°F and -297°F with a density of 4.7 lbs/ft^3.

Another laminate, SI-12, is lighter (2.5 lb/ft^3). But its k factor is 0.11 x 10^{-3} BTU/hr-ft-F° between 80°F and -297°F.

Linde believes the upper operable limit of these insulations is at least 1000°F. This ceiling, largely determined by the materials of construction, could be extended if stainless steel were substituted for the aluminum and quartz fibers were used in place of the glass.



PERFORMANCE OF SI-4 at various boundary temperatures.

The practical problems in the application of the insulations have been resolved. These included maintaining a permanent vacuum, applying the insulation to geometrically irregular contours, and accommodating supports and piping through the insulation. The systems remain vacuum tight without re-evacuation indefinitely under the conditions of shock and vibration encountered in the handling and transporting of the vessels.

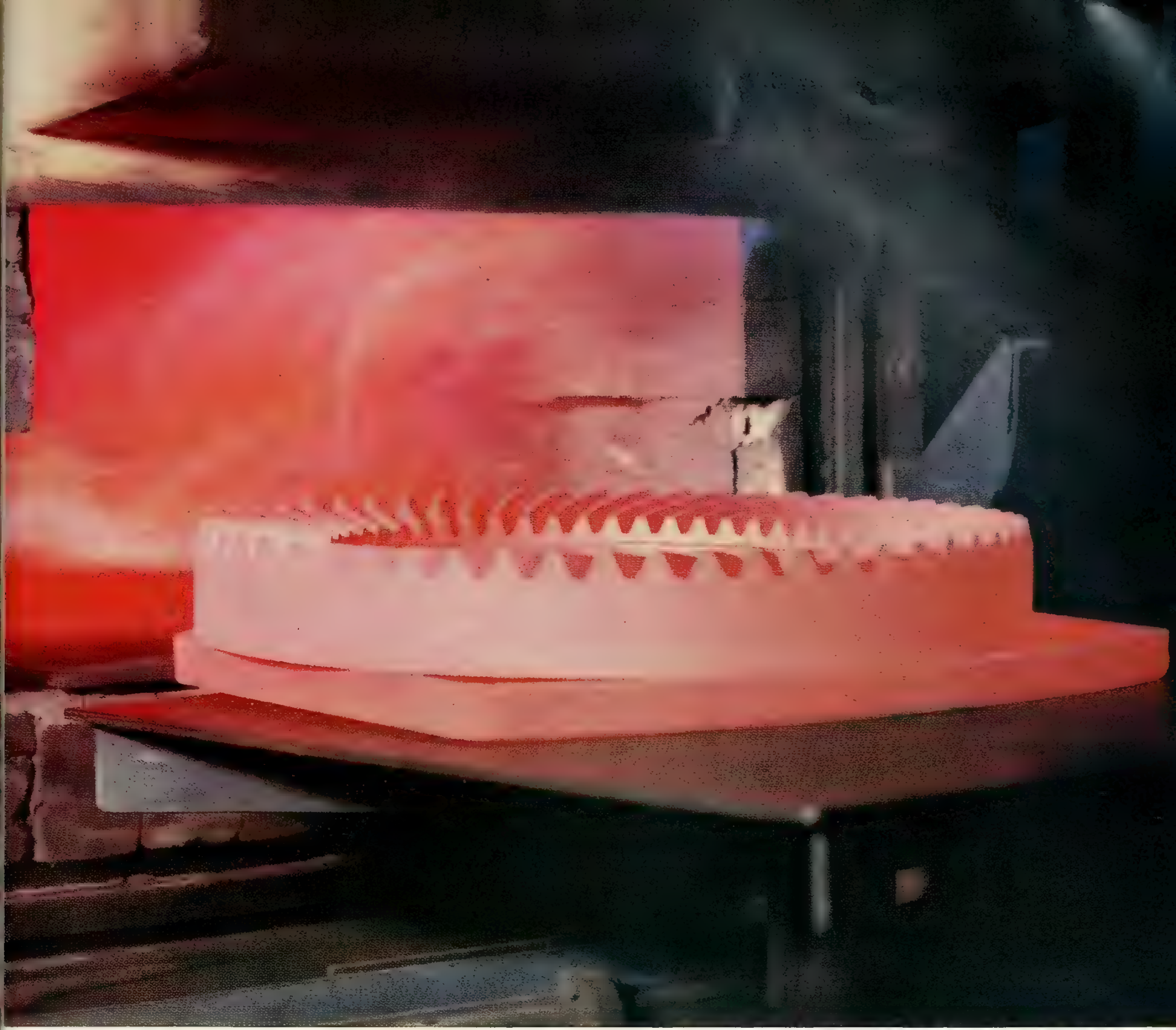
Linde has filed patent applications covering this type of insulation.

Work is progressing on a laminate roughly equivalent to SI-4 but with the cost cut in half.

A lighter insulation (4 lb/ft^3) with a lower thermal conductivity than SI-4 is currently in the laboratory stage of development.

- **High temperatures**—At the other end of the insulation picture **Johns-Manville** approaches the problem in a diversified manner.

Min-K, a molded, low-conductivity material, and Min-Klad interlock, an integrated structural material which combines reinforced plastic with



This large concave spiral bevel gear is so distortion free after heat treatment that it meets the highest aircraft gearing standards without subsequent tooth grinding.

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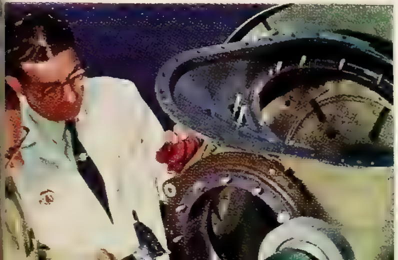

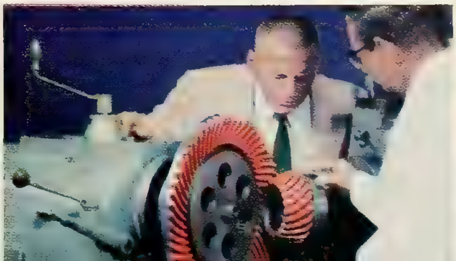

clarifying the comparisons . . .

Min-K are two of the company's developments applicable to missile insulation.

Both of these are being considered for cryogenic applications where vacuum systems are unnecessary. For vacuum areas, the standard glass paper used as a spacer between foil radiation elements employs extremely fine diameter micro fibers produced by the Johns-Manville Fiber Glass Division.

• **Companies involved**—Many firms, besides Linde and Johns-Manville, are engaged in supplying the insulation demands of the missile/space industry. While it is impossible to list them all, here are a few of the more familiar: **Taylor Fibre,** in high-temperature laminated plastics; **H. I. Thompson Fibre-Glass,** producers of Refrasil and Astrolite; **Continental-Diamond Fibre,** makers of molded and flexible insulations; **Hooker Chemical,** producers of the Durez line of heat-resistant phenolic resins, and **General Electric** and **B. F. Goodrich** in the field of reinforced plastics for re-entry applications.

• **Insulation comparisons**—Scientists at both Linde and Johns-Manville expressed concern over the confusion existing in attempts to compare various recent insulation advances.

Normally, the effectiveness of any specific insulation material or system is judged by the rate of heat flow through it during a steady application.

Dr. S. Speil of the Johns-Manville Research Center explained that there are three distinct definitions of heat flow in normal use—conductivity, conductance and transmittance. He listed them as:

• Conductivity, per se, refers only to a homogenous material or system and is a measure of heat flow through a unit size system based on unit difference in temperature between two surfaces.

• Conductance is a measure of the heat flow through any system irrespective of homogeneity or dimensions per unit area—based on the unit difference in surface temperature.

• Transmittance is the overall measure of the heat flow through a unit area of any system based on unit difference in temperature between the two air (not surface) temperatures. It is markedly affected by many ambient and surface considerations.

• **Meters and feet**—The familiar k factor, usually expressed as BTU/hr-ft-F°, applies to the definition of heat flow in terms of conductivity.

Some of the confusion arises from the many mathematical substitutions and conversions available in the k factor equation. For example, another method of expressing the thermal conductivity is in microwatts/cm-C°. But this, says Linde's Dr. E. L. McCandless, is only the normal confusion inherent in a scientific society which refuses to stabilize its system of measurements.

The insulation issue, however, is clouded by the choice of temperature difference. This difference is an essential part of each of the three basic definitions. It does not require much imagination to see the effect on the k factor of an intelligent choice in temperature gradients. Its presence is mandatory if any comparison between insulations is to be attempted.

• **Comparison dangers**—Either surface temperature, says Dr. Speil, or drop in temperature across an insulation is an extremely poor and often contradictory measure of the effectiveness of a thermal insulator. It must always be accompanied by a complete enumeration of the test conditions and is very difficult to correlate with other data obtained under different test conditions.

Furthermore, he says, extrapolation of conductivity data beyond the actual measured range when any change in density or temperature is involved is definitely hazardous, and, in most cases, wrong—unless sufficient data are available to express the conductivity in a mathematical relationship. Even in this instance, the extrapolation cannot be extended beyond the point where the density and the thermal radiation change markedly.

In general, a valid comparison of insulation systems involves more than the k factor. In fact, as Linde points out, if the relative merits of cryogenic containers are involved, convection and radiation are also important.

Perhaps, suggests Dr. McCandless, the best measurement in this area would be the relation of heat leak to contents.

ARPA To Back College Work

New York—Basic research programs in materials will be initiated by the Advanced Research Projects Agency at three to five selected American universities.

Roy W. Johnson, Director of ARPA, said that 25 universities were asked to submit proposals for participation in the project. The new materials program is a result of a recommendation by the President's Federal Council for Science and Technology.

The New York section of the American Chemical Society heard Dr. Johnson explain that there will be a minimum of governmental restriction involved. The research is to continue over a period of years and will incidentally result in the creation of 150 to 200 new Ph.D.'s annually.

ARPA also expects to invest some $32 million in solid propellant research to increase the useful energy of solids by 10 to 20% or more. Johnson said that during 1959, $15 million funded 54 contracts in six broad areas of solid propellant research.

Four of these contracts involved integrated programs totalling $6 million. As a result of an evaluation of the year's work, these four will probably be funded at a slightly higher level while the others will remain about the same.

In addition, Dr. Johnson said, ARPA is negotiating with representatives of the chemical industry for research on the deflagration-to-detonation phenomena, part of a new area of non-destructive testing in solids.

Heat-resistant Ceramic May Be Used in IR Lamps

Schenectady, N.Y.—A new translucent ceramic, developed by scientists at the **General Electric Research Laboratory,** is said to withstand much higher temperatures—up to 3600°F—than most ceramics now in use. The polycrystalline ceramic, made from powdered aluminum oxide, has a high degree of strength and is relatively easy to fabricate.

Called "Lucalox," the material reportedly has the composition of a ceramic, structure of a metal, and light-transmitting ability near that of glass.

Lucalox is closely related to sapphire and ruby gem stones. It could be used as a gem-bearing material in precision equipment, or an electrical insulator. Its most immediate potential appears to be in high-intensity incandescent and discharge lamps, now limited by the temperature sensitivity of their transparent envelopes. Infrared lamps, especially, used for heat-resistance testing of missile nose cones and space vehicle equipment, would be a possible application. The "glass' usually used is fused quartz which is limited to temperatures below about 1800°F.

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NASA About To Try Orbit Near Venus

Thor-Able launching next month would be trackable beyond 50 million miles; success would restore much lost U.S. prestige

by C. Paul Means

WASHINGTON—An attempt will be made in November to launch a solar satellite capable of being tracked at distances greater than 50 million miles.

The National Aeronautics and Space Administration will make the solar orbit attempt with a *Thor-Able* vehicle that was originally scheduled to launch a payload towards Venus last June.

If successful, the *Thor-Able* payload will be the first to send back information from any great distance of solar space. Coupled with a successful launching of the *Atlas-Able* moon orbit shot, scheduled for the favorable astronautical times in either early or late November, the solar satellite would enable the United States to recoup some of its lost prestige in the race to space with the Soviet Union.

The payload is scheduled to be launched into an orbit inside of the earth's and very close to the orbit of Venus. How close the man-made planetoid will come to Venus has not been disclosed.

If accurate information is obtained about the satellite's orbit, it will be possible to receive information from it any time it comes within 50 million miles of the earth, giving scientists a solar observation platform which will continue to furnish information for years to come.

- **Other duties**—Principal objectives of *Thor-Able IV*, aside from any information it may be designed to pick up about Venus, will be the study of interplanetary gas and solid particles, and the study of solar-terrestrial relationships.

Studies by Van Allen in the earlier earth satellites indicated that the sun emits quantities of plasma gas into the solar system, some of which is captured by the earth's magnetic field to form belts of charged particles.

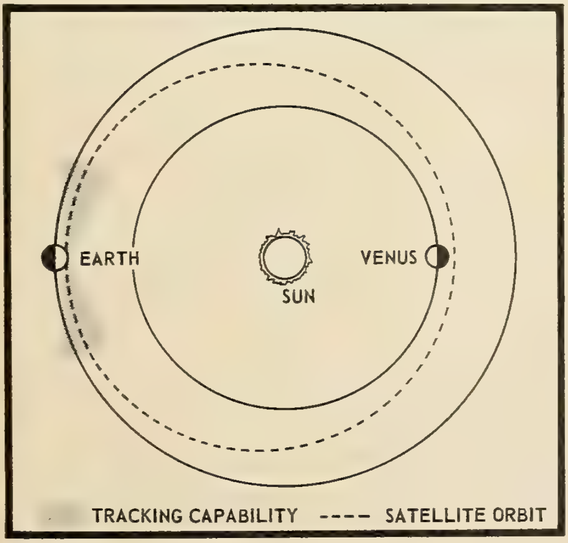
These streams or fields of gas will be studied by a magnetometer possessing a sensitivity of at least 10^{-5} Gauss.

The satellite will also study the magnetic fields of the plasma globs floating through interplanetary space from the sun and try to determine what the mechanism is for the propagation and transportation of the plasma streams from the sun to the earth and into the rest of the solar system.

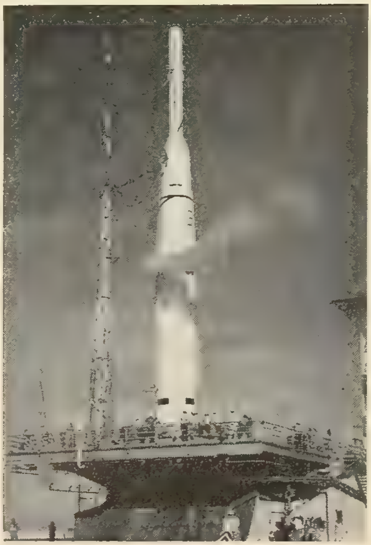
The satellite's instrumentation will also observe meteorites and dust particles in solar space outside the earth's gravitational field. And it will collect data on the sun's ultraviolet and X-ray regions, which when correlated with the plasma and meteorite information, should give a clearer picture of terrestrial relationships.

- **Special equipment**—The *Thor-Able IV* payload is similar to the "paddlewheel" payload developed by **Space Technology Laboratories** for *Explorer VI*, with two of the most important features being the solar cells and the transmission equipment.

The solar energy converters, manufactured by the **Hoffman Electronics Corp.**, are tiny wafers of specially treated silicon, which when exposed to



← *SOLAR ORBIT* **of proposed satellite would, if successful, provide an observation platform for many years to come.**



→ **FORERUNNER of the planned vehicle was *Thor-Able III*, shown on launch pad prior to boosting *Explorer VI* into orbit Aug. 7.**

light, convert approximately 10% of the energy of the light into electrical energy. *Explorer VI* used 8000 of these cells, 1000 on each side of the four paddles.

These cells will allow *Thor-Able IV* to transmit signals in its orbit around the sun indefinitely.

Helping to transmit the information received by the satellite's instruments is a compact telemetric digital unit called "Telebit," developed by STL. This instrument, designed to transmit information over interplanetary distances upward of 50 million miles, collects, stores, and tallies data while the transmitter is off, and sends the totalled information by radio signal to earth when the transmitter resumes operation.

Initial design and development of the sun satellite experiment began in late 1958 when NASA and the Air Force's Ballistic Missile Division assigned major tasks of the project to STL.

Thor-Able IV was to have been part of a three-stage project to investigate Venus last June, when the earth's sister planet was at its closest proximity to earth. The two other vehicles were *Explorer VI* (*Thor-Able III*) and the *Atlas-Able* vehicle which will now attempt to orbit the moon. The project was called off when *Thor-Able III's* payload could not be readied in time.

Shorter Method Developed for I_{sp} Hand Calculation

DOVER, N.J.—A rapid method of approximating machine calculations of I_{sp} has been developed by John D. Clark of the Naval Air Rocket Test Station.

The "NQD" method (NARTS Quick and Dirty) permits the consideration of novel propellants without the expense of machines and the drudgery of complete hand calculation.

Clark said the NQD method was faster and more accurate than the old Reinhardt System. All the new system involves is four sheets of thermodynamic data, a nomograph for solving one equation and a knowledge of arithmetic.

NQD is suitable for screening, Clark added, but inadequate for design purposes since it yields no information as to the actual state of affairs in the combustion chamber.

Based on a thermal equilibrium hypothesis, NQD utilizes the exhaust conditions as a direct route to I_{sp}. Clark considered special cases such as condensates and insulated particles, but he is skeptical of the validity of the former.

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propulsion engineering

By JAY HOLMES

The Navy's new 'miracle' liquid monopropellants . . . have a specific impulse ranging from 249 to 255 pounds of thrust for each pound per second of fuel consumed. This is a quantum jump of at least 20 and perhaps 60 seconds over nitromethane, the best existing monopropellant. It pulls monopropellants even with—and perhaps ahead of—the best storable liquid fuel-plus-oxidizer bipropellant systems. For it isn't necessary to match the specific impulse of a bipropellant to be competitive. The weight saving in one set of pumps, hose, tank, etc., accounts for many seconds of I_{sp}.

Security still shrouds the exact composition. . . of the new monopropellant family. Monopropellants are compounds whose molecules have fuel on one end and oxidizer on the other. You can think of them as chemical hermaphrodites. All the Navy will say is that the new compounds consist of carbon, hydrogen, oxygen and nitrogen. Since the same can be said of the chemistry of the human body, not much information is being given away.

Stability is a major advantage . . . The monopropellants can be heated to 320° F for 48 hours without explosion or appreciable decomposition. They are liquid at ambient temperatures (boiling point about the same as water) and freeze from +23° to below −100° F. They appear to be wholly indifferent to ordinary shock. A high-order nearby explosion is necessary for detonation. The compounds can be stored a long time without deteriorating. Corrosion is so low that they can be easily prepackaged.

About 80 compounds were studied . . . before a half-dozen members of the chemical family were found promising during five years of research at the Naval Rocket Test Station, Lake Denmark, Dover, N.J. Two of the best are named *Tallulah* and *Cavea*. Dr. John D. Clark, chief chemist, says their density—ranging from 1.3 to 1.5 gm/cc—gives them a tremendous density impulse advantage. Density impulse, the product of specific impulse and density, is considered a better criterion than just I_{sp} in judging high-performance fuels for certain applications, particularly small rockets. A high density makes it possible to save weight by putting the propellant in a small container.

Monopropellants can't compete with solid propellants . . . in density impulse. But, being liquid, they can be turned off. Navy tests have shown that 93 or 94% of the theoretical impulse can be attained easily in a tube whose integrated length (volume divided by area of cross-section) is as little as 50 inches. Bipropellant systems require much greater length for high efficiency. Clark said specific impulse was figured on a shifting equilibrium basis at the now-standard 1000/14.7 psia.

No one has bought *Tallulah* or *Cavea* yet . . . for use in a piece of hardware. Clark contends they would be ideal for *Nike-Zeus* and *Polaris*. As in almost all cases with new high-performance fuels, first uses would be in upper stages. But he insists a booster could be built too. He even proposes trying *Tallulah-Cavea* in *Minuteman*.

What about cost? . . . Raw materials are commercially available in ample quantity, the Navy says, and the cost in mass production is expected to be no more than $5 or $6 a pound. At least four major chemical companies are capable of doing this job. Clark reports that every company in the rocket business and half of the chemical industry are "breathing down my neck." He says the production method is so simple that "any chemical processing plant above the level of a garage hobby shop can use it."

How To Pick Liquid Tank Materials

An Army expert outlines how compatibility and strength characteristics vary as the chief factors determining a choice of container composition

WASHINGTON—Compatibility and strength characteristics are the major factors in choosing liquid propellant tank materials.

Dr. Wilbur A. Riehl of Army Ordnance Missile Command reported this conclusion in a paper delivered at the Armed Forces Chemical Association meeting. Outlining requirements for all containers, he said cost replaces strength as a major consideration in shipping; the shipping container may be made as heavy as necessary so long as cost is favorable.

In a missile tank, the relative importance of compatibility and strength characteristics depend on the missile's mission. Defining compatibility as the ability of a material to resist chemical reaction with the propellant, Riehl noted that the quality can often be sacrificed for strength when the propellant is loaded a short time before launch. There is not enough time for a slow reaction to occur.

However, for storable propellant tanks, compatibility has just as great importance as for shipping containers. For example, high-purity aluminum containers are used for shipping concentrated H_2O_2, Riehl remarked. But the peroxide container in the *Redstone* is made of high-strength stainless steel, a material not suitable for long-term storage. The overriding consideration here is the greater strength-to-weight ratio of the steel chosen, while the compatibility is sufficient for the short time involved.

Evaluating strength characteristics involves such factors as compressive strength, tensile properties, Young's modulus, ductility and fabrication, Riehl pointed out. These are measured against density, so that the lightest material meeting strength requirements is used.

Strength-to-weight requirements are set in turn by design functions. For instance, the question arises whether the tanks are part of the structure—and thus must bear their share of the load.

A further question is expected lifetime. If a missile is to be storable, and may be subject to rough handling, a greater safety factor is necessary than for space flight, where it may be possible to shave a few pounds by careful handling.

In general, Riehl declared, aluminum alloys and austenitic type stainless steels are compatible with missile propellants, although other materials may be better in special cases. For contact with the halogens, such as liquid F_2 and ClF_3, monel or nickel is preferred. Aluminum or stainless steel may be used for LOX, N_2H_4 and fuming nitric acid.

Prior to use, laboratory tests must be made to establish compatibility with particular alloys. For example, molybdenum in stainless steels appears to react slowly with hydrazine or H_2O_2. Tests would be necessary to determine the exact reaction speed.

Some materials, such as nitrogen tetroxide and unsymmetrical dimethylhydrazine, can be shipped in mild steel containers. Nevertheless, aluminum or stainless steel containers are used. The reason is that both propellants are extremely hygroscopic and increases in water content could result in severe corrosion of mild steel.

The accompanying table shows container material that may be chosen for 10 common liquid propellant ingredients.

Composition of Typical Propellant Containers

	MATERIALS	
PROPELLANT	FOR LONG TIME STORAGE	FOR MISSILE USE
LIQUID O_2	ALUMINUM, STAINLESS STEEL	ALUMINUM, STAINLESS STEEL
LIQUID F_2	MONEL, NICKEL	MONEL, NICKEL, STAINLESS STEEL
LIQUID H_2	MONEL, STAINLESS STEEL	ALUMINUM, STAINLESS STEEL
N_2H_4	ALUMINUM, STAINLESS STEEL	ALUMINUM, STAINLESS STEEL
UDMH	MILD STEEL	ALUMINUM, STAINLESS STEEL
CLF_3	MONEL, NICKEL	MONEL, NICKEL STAINLESS STEEL
H_2O_2	1100 ALUMINUM	ALUMINUM, STAINLESS STEEL
FNA	ALUMINUM, STAINLESS STEEL	ALUMINUM, STAINLESS STEEL
N_2O_4	MILD STEEL	ALUMINUM, STAINLESS STEEL
KEROSENE BASE FUELS	MILD STEEL	ALUMINUM, STAINLESS STEEL

GM Developing Model Satellite Powerplant

INDIANAPOLIS—A model of an earth satellite powerplant—which uses solar, nuclear, or chemical energy as fuel and can operate unattended for two years or more—is being developed here by **Allison Division of General Motors.** A laboratory model already has been operated successfully on solar radiant energy, producing enough power through an a-c generator to operate a small radio.

The Stirling-cycle engine—the principle of which dates back to 1816—operates at a constant speed of approximately 3600 rpm and drives two 12,000 rpm alternators.

The engine operates from external heat produced by solar energy, gases or organic materials. Where solar power is used, a special plastic Fresnel lens 20 feet in diameter concentrates the sun's rays and focuses the energy on a "window" in the engine's heat trap.

This heat is transferred inside the engine head to an operating fluid such as air, helium, or hydrogen. Changes in pressure from expansion and compression within the engine furnish power for the work piston. Solar energy is stored in heat-retaining lithium hydride to supply energy while the satellite orbits on the dark side of the earth.

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soviet affairs . . .

By DR. ALBERT PARRY

What Soviet scientist . . .

has been in charge of calculating *Lunik* trajectories? The answer: V. A. Yegorov, who, although in charge of a group of prominent specialists assigned to this task, is not even a doctor of sciences yet. Yegorov's rank is merely that of the candidate of physical and mathematical sciences, which is less than our doctorate but more than our master of sciences. Yegorov's *Lunik* work is praised in a brief paragraph in a recent issue of *Sovetskaya Aviatsia,* amidst a long article on Soviet lunar rocketry by K. Portsevsky, an astronomer.

From earlier data on the subject . . .

we know that Yegorov is attached to the Steklov Mathematical Institute of Moscow, and that another outstanding expert working with him on *Lunik* trajectories is M. V. Cheldysh of the Soviet Academy of Sciences. They and their staff began their electronic-machine computations way back in 1952. By 1956, they had prepared more than 600 possible trajectories of a rocket flight to the moon, including hits, near-hits, circumflights, and afflights—the latter being approach trajectories, neither touching nor circling the moon, but permitting a view of its far side and a subsequent return to earth. Since 1956, many more trajectories have been added.

Writes Astronomer Portsevsky: . . .

"From among these numerous trajectories, our greatest interest is attracted by those which burn our *Lunik's* fuel the shortest time possible, and which cover the longest part of the route with the aid, not of the rocket's motors (these to be turned off early in the flight), but of the gravity force of celestial bodies." The Soviet astronomer practically dismisses as being of minor importance the influence of the sun on the *Lunik's* movement. But he writes of the necessity to calculate the gravity pulls of both the moon and the earth to a very exact point, indeed. He compares the precision of the Soviet guidance system of each *Lunik* to "the exactitude of a sniper aiming at—and hitting—the eye of a fly one hundred kilimeters away."

Basic discoveries . . .

shedding light on the problems of the origin of the earth and the moon have been made in the course of *Lunik* flights. This was recently announced at a Moscow gathering by Professor Leonid Sedov who, according to *Izvestia,* says that "these discoveries are now being checked, to be made public in the near future when they will become the possession of all the world's scientists."

Changes in the moon's place-names . . .

are soon to be proposed by the Soviet government. This can be deduced from a compaint voiced in *Komsomolskaya Pravda* that too many lunar place-names are meaningless to modern man. The complainer, V. Shishakov, a member of the staff of the Moscow Planetarium, asks indignantly: "Who were those men after whom the moon's mountains and craters are named?" He points out that the long-dead, long-unknown personalities of the seventeenth century, honored by that era's German and Spanish astronomers and mathematicians in devising lunar place-names, do not deserve such laurels in our times. Worse (from the atheistic Soviet view), some of the largest lunar craters are named after monks and other clergymen! Shishakov cites Sacrobosco, Schickhar, and Clavius as lunar names that are too "churchy" in their origin, and therefore simply do not belong on our modern moon. He blames Francesco Grimaldi, a Jesuit of bygone times, for establishing this trend. The Soviet astronomer says that the names of such well-deserving scientists of yore as Copernicus and Kepler "were given to comparatively small craters" of the moon. "Astrological superstitions" were responsible for such names as Mare Crisium. "But," Shishakov consoles his Russian readers, "selenography will soon doubtless be enriched with new names. The pencil of astronauts will put them on the lunar map."

NBS Conducts Broad Study To Aid Understanding of Dielectrics

DOD is sponsoring some of the research seeking materials which will be unaffected by temperature; knowledge gaps must be filled first

WASHINGTON—Because of the increasing demands of the missile and aircraft fields for better dielectric materials, the National Bureau of Standards has been conducting a program of fundamental research.

Partly sponsored by the Department of Defense, the work is aimed toward a greater understanding of dielectric phenomena to improve measurement accuracy and produce materials for severe environmental operation. In particular, dielectrics must be developed having electrical properties relatively free from temperature influence.

Supported by an active theroetical program, the investigations have resulted in development of new laboratory hardware and handling and measuring techniques.

Both the NBS laboratories in Boulder, Colo., and in Washington, D.C., have responsibilities in the current studies.

Primary objectives are to explain observed dielectric phenomena and to develop theories which can be used to predict the behavior of certain materials. In most of the work, a solid state approach is employed to probe the molecular behavior responsible for dielectric phenomena.

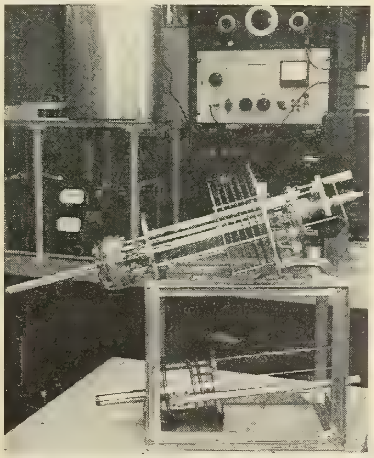
- **Basic studies**—Dielectric phenomena often are associated with a property known as "electric polarization." This is due in part to a displacement of bound charges in molecules when a voltage is applied. Little or no dielectric loss is associated with this contribution.

It also can take the form of interfacial polarization, that is, polarization arising from movement of electric charges on the interface between two discrete phases. Still other electric polarization arises from the presence of orientable permanent electric dipoles in molecules. Loss caused by "frictional" restraint on the motions of the ions or dipoles is associated with these last two types of polarization.

NBS is interested primarily in dipole polarization because it provides a basis for studying both intermolecular and intramolecular motions in such important materials as high polymers and for establishing the relationships which exist between the electrical characteristics and certain chemical and physical characteristics.

- **Special equipment**—A wide variety of special bridges, circuits, holders, transmission lines, resonant cavities, and cells have been put into use to accommodate the frequency and temperature ranges involved in the measurements. Dielectric constants and dis-

DIMENSIONS OF a dielectric sample under consideration are being measured as a reference standard. To insure top accuracy, NBS uses traveling microscope.



DISSASSEMBLED fusion cell (lower end) and controls form principal unit of special holder designed by the Bureau. Outermost housing is at upper left.

SINGLE CRYSTALS of inorganic nonmetallic materials are "grown" at the Bureau. Powdered material drops through flame, melts and forms crystal at base.

environment must be controlled . . .

sipation factors are measured over a frequency range of from 10^{-1} to 10^{-10} cps at temperatures from −100° to +500°C.

Facilities for millimeter-wave work are available at the Boulder Laboratory and studies have been made at the low-frequency end of the dielectric spectrum involving frequencies having extra long periods (over 24 hours).

Although frequency determines the applicable dielectric measuring technique, temperature dictates the structure of dielectric cells. Several systems have been developed by NBS, including dielectric cells with micrometer-electrode holders for use at temperatures up to 500°C and down to −196°C. Two electrodes, one movable and one stationary, are employed to contact the specimen, and a precision micrometer is used to determine the position of the movable electrode.

A "fusion cell" has been designed to study materials that pass from liquid to solid form in the temperature range of interest. Although similar to other holders, the material in liquid phase can be held in the space between and around the electrodes. Pressure is applied to the movable electrode as the sample is solidifying, thus preventing voids from forming as the material contracts.

Current work seeks to determine the effects of solidification on the electrical properties of a variety of interesting materials. (For example, one substance, 2,2-dinitropropane, has a nearly spherical molecule that undergoes rotation in the solid state.)

To study materials involving a transition from gaseous-to-liquid-dielectric behavior, resonant cavities for compressed gases have been developed. Studies have shown that liquid-like behavior can occur at pressures of less than an atmosphere for the strong dipolar gases (ND_3). Further work is being initiated which will determine dielectric losses of very low-loss gases (such as sulfur hexafluoride, which very closely approximates a spherical molecule).

In the study of crystalline nonmetallic inorganic solids, although measuring circuits similar to those mentioned are employed, somewhat different theoretical and empirical problems have been presented. With polymeric materials it is desirable to consider the polarization in terms of molecular structure, but here crystal structure is of utmost importance.

Contributions to the dielectric constant arise from electron displacement, local displacements of the nuclei forming the lattice, and migrations of these nuclei to other sites. These contributions will be affected not only by the crystal structure and orientation but also by crystalline defects such as impurities, vacancies, and domain boundaries.

One major difference in experimental technique arises from the high dielectric constant of the titanate materials presently being studied. Instead of employing the micrometer holders used in the other studies, electrodes must be directly bonded to the surface of the specimen. The electrodes are made to cover the entire surface to minimize edge effects.

Because ceramic materials are especially sensitive to temperature and humidity fluctuations, studies must be carried out in a controlled environment. A constant-temperature holder has been developed for use with a Schering bridge. It consists of an inner chamber in which 19 specimens can be maintained simultaneously at 35.1°C by circulating water from a constant-temperature bath.

Between the inner chamber and an insulating outer chamber, a flow of dry nitrogen eliminates humidity effects. A second specimen holder designed for studies of the effect of temperature variation (20° to 200°C) on individual specimens also has been constructed.

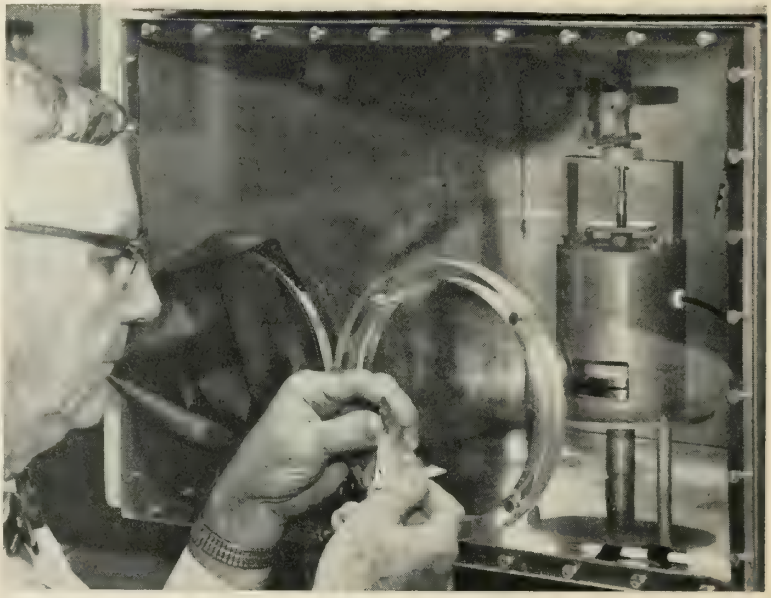
- **Areas of investigation**—An added difficulty in making accurate dielectric measurements on ceramics arises from the large effects of even small changes in specimen fabrication. To compensate for possible error, considerable attention is given to improving measurement techniques and characterizing specimens.

Two efforts are being made in this direction. First, an exploratory program on the effects of the electrodes has resulted in the adoption of indium-gallium amalgam instead of silver as the accepted electrode material. Second, some single crystals to supplement ceramic specimens are being produced with the idea that the crystals will be easier to characterize.

Through these continuous efforts to improve accuracy and reliability, it is hoped that eventually the complete relationship between the composition and electrical characteristics of ceramics can be worked out. For the present, the ferro-electricity group in the Boulder Lab will continue to concentrate on the titanates in general, and on barium titanate in particular. With its aim to provide a better understanding of the dielectric behavior of a single group of interesting materials, this program forms an integral part of the dielectric studies throughout the Bureau.

While ceramics are crystalline by definition, many polymers are neither completely crystalline nor completely amorphous. Therefore, to obtain a comprehensive picture of these materials, it is necessary to determine the degree of crystallinity as a function of such variables as temperature and previous history.

The degree of crystallinity is re-



HUMIDITY CABINET is used at the Bureau to determine the effect of atmospherics on dielectrics under consideration as reference standards.

lated in a simple manner to the density of the polymer. This density is easily measured by weighing the material in silicone oil. As the density of the oil at any temperature can be measured, a means for studying the amount and speed of crystallization in the specimen at various temperatures is thus provided.

A comprehensive set of measurements on polyethylene at temperatures from −50° to 250°C has provided such data on the relationship of specific volume to degree of crystallinity. Dielectric measurements have been made over approximately the same range of temperature, and correlated with the degree of crystallinity.

Similar dielectric measurements are now being made on nylon at temperatures from −100° to 175°C. These measurements are complicated by the appearance of a large dc conductance at the higher temperatures, and by an electret effect (resulting from the permanent polarization of a dielectric).

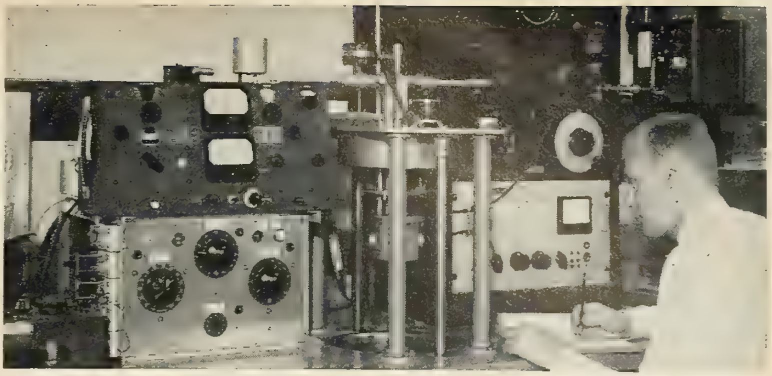
Theoretical studies, which are being conducted to explain the relationship between the electrical properties, the amount of crystallinity, and the effects of temperature, will form a prominent part of the dielectrics program on semicrystalline polymers for some time in the future.

Certain crystals such as sapphire, certain molecules such as the noble gases (helium, argon, etc.), and some other molecules have extremely low loss which can be studied conveniently at microwave frequencies. Also, measurements on very pure aluminum oxide reveal dissipation factors smaller than most materials now known. According to NBS, this demonstrates the possibility of obtaining even lower losses with very pure substances.

Because the theory of these losses is not yet well developed, NBS is conducting theoretical studies and making new and more accurate measurements. Such investigations will have practical applications especially important at higher temperatures where low-loss materials are essentially nonexistent at present. Further work in these areas is dependent upon obtaining pure materials under carefully controlled conditions.

In the interaction between electromagnetic waves, conductivity properties of materials are essentially inseparable from the dielectric properties. At radio and microwave frequencies, conductivity studies are therefore an important component of any dielectrics program.

In this connection, the Radio and Microwave Materials Section is investigating the tensor or directional conductivity of semiconductors such as single crystals of germanium at microwave frequencies under different physical conditions.



SPECIAL HOLDER (center) designed for use from the liquid-nitrogen range up to 300°C, is placed in a Dewar containing liquid nitrogen.

Some important questions in the theory of solid state will be investigated in this work. It is expected that these studies will yield a better understanding of the crystal lattice forces and processes. The results may prove of value in microwave engineering if the tensor properties for radio waves are appreciable.

Among other examples of the Bureau's research in dielectrics are refractometer studies. The refractometer determines the dielectric properties of the atmosphere, which in turn determine the propagation characteristics of the troposphere, so important to radar and other means of microwave communication. The Bureau's work constitutes the background for successful applications in this field for military and other purposes.

Propagation of electromagnetic waves or radio signals through a material is governed by the product of the material's magnetic permeability and its dielectric constant. For many substances the magnetic permeability is unity. In such cases the travel of waves in the material is dependent only on the complex dielectric constant of the ability of the material to "store" electrical energy.

Ferrites have important magnetic properties at radio and microwave frequencies and have gyrotropic or directional characteristics important in microwave applications. They also have very high dielectric constants which are currently being investigated. Studies on soils are important in locating radio transmitters and antennas and establishing and predicting radio communication links.

- **Standardizing measurements**—Accuracy in dielectric measurements is basic to all electrical applications, where dielectrics often set limits on voltage, frequency, absorption, reflection, and temperature of operation.

For this reason, the electrical properties of dielectrics must be determined before the materials are incorporated in electrical equipment such as capacitors, transmission lines, antennas, transmitters, transducers, and generators. Furthermore, as small changes in production techniques may radically alter the electrical properties of the material, additional measurements are sometimes necessary to control the quality of finished equipment.

A principal task at the Bureau is its effort to meet the ever-increasing need for accuracy and reliability by improving measuring techniques and developing reference standards. This work is carried out principally by the Dielectrics Section in the Washington laboratories and the Radio and Microwave Materials Section in the Boulder laboratories.

The Boulder laboratories are responsible for dielectric tests and standards at and above 30 kc, and the Washington laboratories are responsible for similar work at lower frequencies. In addition, results obtained by the Bureau's chemistry laboratories in research on molecular dynamics are frequently applicable to standardization procedures.

In further efforts to assure accuracy, the Bureau is cooperating with the American Society for Testing Materials in developing improved techniques for two-terminal measurements and for dielectric measurements of microwave ferrites and ceramics.

Through this comprehensive program of dielectric activities, which begins with the development of a primary standard, extends through improved measurements, and results in materials data and an understanding of fundamental behavior, the Bureau provides the basis for the technological application of dielectric materials. Efforts will continue along the lines described, with emphasis continually shifting toward basic studies as the accuracies necessary for the effective application of data are realized.

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—contracts

NAVY

Aircraft Armaments, Inc., Cockeysville, Md., for design and development of an operational trainer for the Army's *Sergeant* weapon system. Amount not disclosed.

Packard-Bell Computer Corp., for the development of a high-speed analog-to-digital conversion system. Amount not disclosed.

United Aircraft Corp., Sikorsky Aircraft Division, Stratford, Conn., for manufacture and delivery of booster fins for the *Talos* guided missile. Amount not disclosed.

$8,000,000—**Aerojet-General Corp.,** Sacramento, Calif., for development of a high-performance rocket powerplant for the *Eagle* air-to-air missile. Subcontract from **Grumman Aircraft Engineering Corp.**

$906,650—**The Singer Manufacturing Co.,** Bridgeport, Conn., for six hundred AN/ASR detecting equipment and related items.

$240,098—**Webcor, Inc.,** Chicago, three hundred sixty-eight magnetic tape recorders less control and indicator.

$200,000—**Ruscon Construction Co.,** Charleston, S.C., for construction of motor inspection building for *Polaris* missile assembly.

$124,347—**Westinghouse Electric Corp.,** Aviation Gas Turbine Division, Kansas City, Mo., for manufacture and assemble propulsion units.

$73,343—**National Research Corp.,** Cambridge, Mass., for establishing procedure for the production of high purity ultrafine powders of the metals of high melting point.

$52,050—**Bell Aircraft Corp.,** Buffalo, N.Y., for one hundred fifty KY-55/ARW decoders and one hundred fifty MT-950/ARW mounts.

$40,965—**Metlab Co.,** Philadelphia, for services and material required to heat-treat Tartar dual thrust rocket motors.

$40,480—**Ampex Corp.,** Washington, D.C., for magnetic tape recorders.

$31,752—**Valley Pressed Metal, Inc.,** Cornwells Heights, Pa., for the manufacture and assembly of complete guided missile container.

$28,475—**Kin Tel Division, Cohu Electronics, Inc.,** San Diego, Calif., for digital voltmeter.

NASA

$171,870—**Western Electric Co., Inc.,** N.Y., for assembling and operating a transmitting and receiving facility.

$300,000—**Bendix Aviation Corp.,** Baltimore, for call orders in connection with a satellite tracking program.

$72,962—**Republic Aviation Corp.,** Long Island, N.Y., for carrying out a program for accurate determination of the position and velocity of a lunar or interplanetary space probe.

MISCELLANEOUS

$270,000—**Consolidated Avionics Corp.,** subsidiary of **Consolidated Diesel Electric Corp.,** Westbury, N.Y., for special dual-output airborne transistorized power supplies. Subcontract from **Loral Electronics Corp.**

ARMY

$2,795,193—**Raytheon Mfg. Co.,** Waltham, Mass., for engineering services in connection with the *Hawk* missile.

$500,000—**I.T.T. Laboratories Div., I.T.T. Corp.,** Nutley, N.J., for ground stations modification for *Courier* communication satellite system.

$213,272—**The Martin Co.,** Orlando, Fla., for concurrent repair parts for the *Lacrosse*. (Two contracts.)

$117,610—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for research investigations leading to development of solar regenerative chemical system.

$59,048—**Emerson Electric Manufacturing Co.,** St. Louis, for research and development of booster metal parts for missile "A" rocket.

$50,297—**Consolidated Electrodynamics Corp.,** Pasadena, Calif., for a 16-channel, cathode ray, recording oscillograph.

$49,157—**Mathewson Tool Co.,** Orange, Conn., for launchers and spare parts, plus effect of producibility study contract.

$30,441—**Tung-Sol Electric, Inc.,** Newark, N.J., for electron tubes.

AIR FORCE

The Rucker Company, Oakland, Calif., for twelve additional hydraulic power systems for *Atlas* ICBM launching sites. Amount not disclosed.

United Aircraft Corp., Missiles & Space Division, E. Hartford, Conn., for feasibility study of ballistic missile defense equipment.

$38,900,000—**Raytheon Mfg. Co.,** Waltham, Mass., for production of doppler radars for bombing navigational systems. Subcontract from **Sperry Gyroscope Co.**

$1,700,000—**Reeves Instrument Corp.,** Subsidiary of **Dynamics Corp. of America,** for production of various systems including support equipment and airborne inertial devices for the *Discoverer* project.

$1,242,000—**Kearfott Co., Inc.,** subsidiary of **General Precision Equipment Corp.,** Little Falls, N.J., for a product improvement program on the true heading computer group comprised of the AJA-1 and the N1 directional gyro compass system.

$155,000—**Consolidated Avionics Corp.,** Westbury, N.Y., for delivery of a 20-channel analog-to-digital conversion system to be used as an on-line force and moment readout system for a hypersonic wind tunnel.

$110,000—**Electronic Associates, Inc.,** Long Beach, N.J., for precision AC digital voltmeters to be used with TM-76 *Mace* missile program. Subcontract from **Martin Co., Baltimore.**

$99,800—**Kearfott Co.,** Little Falls, N.J., for a solid state multiheaded celestial comparator.

$99,200—**Giannini Controls Corp.,** Pasadena, Calif., for services and material to repair control gyros.

$88,680—**The University of Washington,** for research on "Theory of Molecular Electronic States."

$85,383—**Texas Instruments, Inc.,** Dallas, for control units used with radar equipment.

$42,000—**Massachusetts Institute of Technology,** for investigations on problems of ordinary shock waves, without the effects of magnetic fields or chemical reactions.

$40,985—**Stanford University,** Stanford, Calif., for research on "Non-Linear Control Systems."

$38,574—**University of Illinois,** for continued basic research into internal friction (the damping of elastic vibrations) in metals.

$36,016—**Cosmos Industries, Inc.,** Long Island, N.Y., for test oscillator, spare parts, engineering data and maintenance data.

$27,000—**Electro-Mechanical Research, Inc.,** Sarasota, Fla., for calibrator and transmitter.

$26,355—**Sylvania Electric Products, Inc.,** N.Y., for electron tubes.

$20,000—**University of New Hampshire,** for research involving a theoretical investigation of transport phenomena and the general mechanism of conduction in gaseous plasmas and in solids.

$14,500—**Yale University,** for basic research investigating the kinetics of reactions in gases.

$14,000—**Texas A & M Research Foundation,** for continued basic research on nuclear magnetic resonance.

$12,000—**University of Wisconsin,** for conducting basic chemical research.

$10,000—**University of Minnesota,** for research in basic chemistry.

$9,000—**University of Wisconsin,** for basic research in chemistry involving chain addition reactions to hydrocarbons.

Richard W. Powell, an authority on infrared devices, has been named manager of Aerojet-General Corp.'s Avionics Division.

POWELL

Powell, who joined Aerojet in 1950, was named chief engineer, Electronics and Guidance Division in 1954, supervising research, development and pilot production of infrared systems and sub-assemblies. Prior to his recent appointment he was assistant manager of Avionics.

Hughes Aircraft Co. has announced formation of an advanced program development operation within its Airborne Systems Group, naming: **C. Gordon Murphy,** formerly of the Washington, D.C. office, manager of the operation; **William A. Van Allen,** head of contracts for the Airborne Systems Group; **Barney E. Turner,** manager of Air Defense Systems; **Dr. Norman E. Peterson,** manager of Tactical Systems; **Dr. Rex C. Mack,** manager of Space and Ballistic Missile Systems; **Paul S. Visher,** manager of the Subsystems Dept.; **Malcolm D. Hudson,** manager of Microwave Products, and **Benjamin W. Davis,** manager of Nuclear Electronic Products.

George Morrison, propellant expert, has been named the first associate technical specialist in the technical service and development department of The Dow Chemical Co. Morrison, who joined the firm in 1945, has been assigned to developmental activities in high-energy fuels, explosives, missile propellants and metal hydrides.

Fred Wolff, formerly a staff engineer with Servo Corporation of America, has been named acting manager of the Data Systems Engineering Division of the firm.

Prior to joining Servo, Wolff was chief engineer, UAC Electronics Div., Universal Transistor Products Corp. Two transistor circuits he developed while with Universal have been patented. Earlier, he supervised research and development at Freed Transformer Co.

Telemeter Magnetics, Inc., has awarded UCLA a $9000 grant-in-aid for engineering research in the field of digital data storage and handling. The grant was awarded to **Melvin Breuer,** graduate engineering student, who will receive $3000 annually for research in the field with emphasis on input-output problems. Dr. Gerald Estrin, Professor of Engineering, will direct the project.

Peter H. Escher has been elected manager of the newly formed Electronics Systems Division of Electro-Optical Systems, Inc. He will be concerned with problem analysis and system design of guidance and control equipment for space vehicle application.

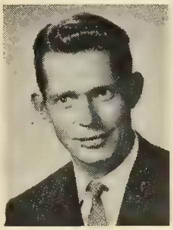
Prior to joining the firm in April, as a senior staff scientist in guidance control, he was manager of the Electro-mechanical Division of Aerophysics Development Corp.

Claire A. Stepnitz has been elected supervisor of research and development for Bowmar Instrument Corp.

STEPNITZ

Stepnitz joins Bowmar after eight years in supervisory capacities at the Federal Division (formerly Farnsworth Electronics Co.) of IT&T Corp., where he specialized in radar systems and missile test equipment. He served as system engineering manager on *Bomarc* missile test equipment and electrical equipment programs. He was also project engineer and section head on several electromechanical projects and on the development of an airborne radar antennae control system.

Dr. Hugh L. Cox has been appointed lead engineer on advanced classified projects by Martin Co., Denver.

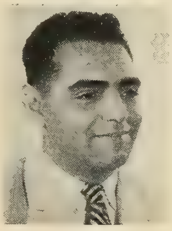


COX

Dr. Cox' new post comes to him after a three-year association with Kirk Engineering, during which time he was assigned to Martin Co. as a consultant in dynamics and structures. During this time he worked on stand vibration analysis for the *Titan* missile.

Prior to his association with Kirk, which he will continue on a consulting basis, Dr. Cox was with ABMA in the capacity of structures and dynamics engineer.

Nicolas G. Sakiotis, formerly associated with the Naval Research Laboratory in Washington, D.C., has been appointed project leader in the Microwave Applications Laboratory of the Motorola Solid State Electronic Department.



SAKIOTIS

Sakiotis will conduct advanced investigations on microwave properties of solid-state materials, ferrites in particular, as applied to switching circulator techniques, ferrimagnetic limiters and phase shifters for antenna scanning.

In 1959 he received the NRL Incentive Award and the Scientific Research Society of America's Applied Science Award for professional achievement.

The following appointments have also been announced:

George H. Lockwood has been named manager of development and research for The Heald Machine Co.

John W. Rane, Jr., formerly of Bell Aircraft Corp., has been elected director of military relations for Ryan Aeronautical Co.

Dr. George K. Hess, Jr., previously on the staff of the Los Alamos Scientific Laboratory and associated with projects devoted to designing and testing atomic and hydrogen devices, has been appointed staff assistant to C. M. Edwards, associate director, technical, of the Research Laboratories Div. of Bendix Aviation Corp.

William O. Laande, former engineering representative and Boeing Aircraft instrumentation specialist, has joined Packard-Bell Electronics as liaison engineer.

Michael Leavitt, formerly with Laboratory for Electronics, has joined the staff of Burnell & Co. as supervisor of operations.

Jules M. Kleinman, previously with Hoffman Laboratories, has been elected president and director of engineering at Mini-Rad, Inc.

Wells R. Chapin has been appointed manager of marketing for Dage Television Division, Thompson Ramo Wooldridge, Inc.

IBM Corp. has announced the following promotions: **Raymond G. Fox,** business and fiscal manager; **Philip N. Whittaker,** manager of contracts, and **Fred G. Bergheim,** manager of Ballistic Missile Early Warning Systems administration.

Dr. Donald S. Arnold has been named manager of research at American Potash & Chemical Corp.'s Trona, Calif., plant.

Robert G. Parks, formerly with the Electrodata Div. of Burroughs Corp., has been named senior project engineer at Neff Instrument Corp.

The Sheffield Corp., subsidiary of Bendix Aviation Corp., has named **William I. Wilt** vice president in charge of advertising and sales promotion and **Louis Polk, Jr.** vice president-manager of gaging and automation systems.

Stephen F. Leo, formerly special assistant to the Secretary of the Air Force, has been elected to National Research Associates, Inc. board of directors.

Dr. Leonard Pode, formerly with the Norair Division of Northrop Aircraft Co., has joined General Controls Co. as chief engineer of the electronic systems division.

Resin Coating Adds Flexibility

A new line of resin coated fabrics has been announced by the **Irvington Division** of **Minnesota Mining and Manufacturing Co.**

Called "Irvington" brand coated fabric 4222, the material is coated with a modified polyester resin applied to nylon, dacron and glass cloth or other types of farbics in various weaves to provide desired burst and tear strength properties.

It has sunlight and ozone resistance, remains flexible at –80°F and will operate at 375°F without degradation, and resists mildew, wind and salt water. It also offers abrasion resistance and high adhesion to base cloth.

The new fabric has solvent resistance to aromatic, aliphatic, ketones and esters at room temperature. It is resistant to jet fuels, synthetic ester oils and hydraulic fluids as well.

Flexibility of the material is permanent since it contains no plasticizers which could bleed out with age.

The material is described as having excellent sewability and can also be cemented with adhesives having the same general properties.

"Irvington" 4222 is currently available in various colors on nylon, dacron, and glass cloth in 7 and 14 oz./sq. yd. coated weight. Characteristics of the material lend it to applications in missile covers, fuel cells, protective clothing, diaphragms, ducting, splash curtains and others.

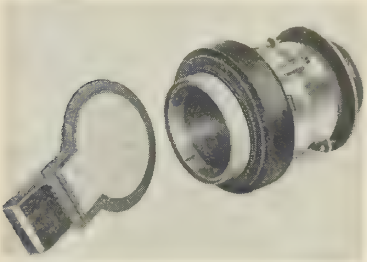
Minnesota Mining and Manufacturing Co.
Irvington Division
900 Bush Avenue
St. Paul 6, Minn.

Cooling Coupling Meets Missile Requirements

A new line of extremely lightweight remote-operated quick disconnect ventilating couplings has been announced by **On Mark Couplings, Inc.**

Available in 2½", 3½" and 5" sizes, the coupling gains its light weight from the airborne half which is made of magnesium alloy. The airborne half is contoured to the configuration of the missile. The simplicity of both the airborne and socket halves of the coupling results in a high degree of reliability.

The new On Mark coupling, designated type 5-8092-80, is disconnected remotely by means of a lanyard or by compressed air prior to launching of the missile. Positive disconnection is accomplished by an ejector which provides the dual function of ejection and protecting the nose of the socket when it is not engaged.



Connection or disconnection is indicated remotely by approved switches installed within the socket. The coupling will operate in spite of freezing conditions and will resist the high temperatures encountered by missiles and satellites.

On Mark Couplings, Inc.
Los Angeles, Calif.

Portable Hydrocarbon Detector Is Versatile

A completely self-contained portable Hydrocarbon Detector affording rapid analysis of total organically bonded carbons in atmosphere or gases has been developed by **Perkin-Elmer Corp.**

Unique characteristics of the new instrument make it highly suitable for use as an atmospheric monitor of air pollution or lower explosive limits. The unit, which has been designated the P-E Model 213, will also serve effectively as a leak or impurity detector in lab, field and processing systems. Cost of the instrument is less than a third that of equipment normally employed in these functions.

Sensitivity of the new instrument is better than 0.1 parts per million for such organic carbon compounds as hydrocarbons, aldehydes, ketones, alcohols, and amines. It is completely free of interference from such common backgrounds as water vapor, oxygen, nitrogen, CO_2 and rare gases. The range of the Hydrocarbon Detector may be adjusted from as low as 0-to-1 ppm up to 0-to-10%.

In addition to its speed, range, sensitivity and portability, the P-E Model 213 is a rugged and highly accurate unit; identical results were produced on group of samples after the unit was transported across the country as ordinary baggage. Maintenance requirements are negligible and—of vital importance—it can be operated by nontechnical personnel with only thirty minutes of instruction.

The heart of the new instrument is the Flame Ionization Detector, recently incorporated in Perkin-Elmer's gas chromatographic instruments. A metered flow of sample is fed into a hydrogen flame in an enclosed chamber. The flame ionizes combustibles in the sample to effect changes in current flow of a surrounding electrical field. These changes are proportional to total carbon content of the sample. Results are read out on the Detector's meter or an attached milliamp or millivolt recorder.

The P-E Model 213 is housed in sturdy suitcase-type enclosure of durable aluminum measuring 18 x 13 x 8 inches. It weighs 47 pounds fully equipped with batteries and air, hydrogen and standardizing gas clyinders. Air supply, with normal operation, will last 18 hours; hydrogen supply and batteries have average service life of 180 hours; and calibrating gases will last a year. All are of standard types, readily available from suppliers.

The Hydrocarbon Detector incorporates all necessary features to ensure reliability and safety. It may be operated with a hand or motor-driven pump for use with unpressurized samples.

Perkins-Elmer engineers foresee a tremendous scope of application for the Model 213. Combustion engineers will use it to control efficiency.

Perkin-Elmer Corp.
Norwalk, Conn.

SMPTE Hears of Space Age Challenge

by an M/R Correspondent

NEW YORK—Engineers who in the past have contributed to research, development and refinement of the television industry must return to their laboratories to produce new image-sensing devices for space exploration.

Sidney Sternberg, chief engineer of Astro-Electronic Products Division, **Radio Corporation of America,** made the observation after the first "Space Age" technical program of the Society of Motion Picture and Television Engineers held here recently.

Sternberg was program chairman for the session in which papers were presented on a wide variety of topics calculated to acquaint the SMPTE with problems of Space Age image-sensing and instrumentation.

"More sensitivity, higher resolution, much broader spectral response, more gray levels, variety of frame rates will become musts," Sternberg said. "Broadcast standards will no longer hold for space use."

A new electrostatic imaging and recording device being developed by three RCA engineers was described in a paper presented by one of the researchers, Dr. E. C. Hutter. Working with him are J. A. Inslee and T. H. Moore, also of the Company's Astro-Electronic Division.

The sensing device is being engineered for satellite use and one RCA official called it "the most advanced work in this field."

The electronic camera focuses on a special film which consists of a four-layer sandwich. The base of the film is a layer of transparent Conar 60 to 125 microns thick. Light passes through the Conar, then through a transparent conductor layer of gold, 0.01 micron thick. Next it passes through a layer of SbS_3 2.0 micron in thickness. The electrostatic image is deposited on a layer of polystyrene 0.6 micron in thickness.

The image is read off by a scanning electron beam.

In the laboratory model described by the three scientists in their paper, the electronic elements are built into a glass vacuum tube roughly similar in shape to a mushroom. The "stem" is a television pickup tube containing an electron gun. The "head" contains the roll of electrostatic film-tape mounted in an automatic assembly for winding and re-winding during exposure and readout, somewhat in the manner of standard motion picture film.

A company spokesman said advantages include extreme simplicity and durability, large picture capacity, widely variable speed of operation, and reduced sensitivity to radiation effects in space.

A continuous strip of pictures showing cloud formations completely around the earth could be contained in 180 feet of tape, which could be carried in a camera only slightly larger than the present laboratory test models.

Dr. Hutter said the new film has stored its images up to two weeks under laboratory conditions, and "theoretically could store them for months."

The film retains high image density, he said, but some image loss is realized during the electron scanning. A company spokesman told M/R this loss is no higher than the loss in other image transmission systems now in use.

• **Project** *Tiros*—Information concerning NASA's Project *Tiros* was included in several papers presented during the day, with emphasis on the scanning satellite's special equipment.

David S. Johnson, of the U. S. Weather Bureau in Washington discussed "Image Sensing as Applied to Meteorological Satellites."

He told of a cloud imaging system now under development for *Tiros* by RCA. It will view the earth through two television cameras with optic axis coincident with the spin axis of the spin-stabilized satellite. *Tiros* would be orbited at an elevation of about 400 nautical miles.

A high-speed shutter would minimize image smearing.

A 500-line raster would be used with a vidicon tube, and the signal would be stored on a tape recorder for subsequent playback when the satellite is interrogated by a ground readout station.

Each camera would take 34 pictures at approximately 30-second intervals during a selected part of each orbit.

One camera utilizes a lens with an included angle of 104 degrees, resulting in a picture approximately 800 miles square when the optic axis is normal to the earth's surface. Johnson pointed out, however, that area coverage would increase and resolution would decrease when the optic axis is not normal to the earth's surface. The second camera system would take magnified pictures about 30 miles square in the center of the area photographed by the first camera, enabling meteorologists to identify cloud types.

Johnson said that the *Tiros* electronic scan systems are limited to daylight operation. Recent laboratory results hold promise for high sensitivity, image orthicon image converter tubes for nighttime use, at least with moonlight, he said.

Magnetic tape recorders will be used in *Tiros*, Johnson said, but storage of 10^9 bits of data in one orbit, pending ground interrogation of the satellite, makes it doubtful that magnetic tapes are practical for worldwide meteorologic coverage desired. He cited the work of Hutter, Inslee and Moore on RCA's electronic camera as a possible solution for future satellites.

Dr. R. A. Hanel, of the Goddard Space Flight Center, NASA, in discussing "Infrared Imaging from Satellites," cited *Tiros* as a step toward infrared mapping at various spectral bands.

Tiros will scan the earth with medium resolution of about 30 by 30 miles in five spectral regions, Dr. Hanel said.

These are 0.2 to 5 microns, which covers about 99% of solar radiation; 7 to 40 microns, which measures the earth's "black body" temperature; 8 to 12 microns, the atmosphere window which yields surface temperature as well as day and night cloud cover; 5.6 to 7 microns, characterized by strong water vapor absorption; and .55 to .75 microns, a reference close to the spectral response of the eye. The last range will be helpful in interpretation of the other channels, and will also yield daytime cloud cover.

W. G. Stroud, also of the Goddard Center, co-authored the paper presented by Dr. Hanel.

• **Other NASA Plans**—Dr. N. G. Roman, head of the observational astronomy program at NASA, discussed long-range objectives in astronomy, and detailed the limitations of observatories on earth. NASA plans include a Gamma ray astronomy project to measure spatial frequency distribution of very high-energy photons.

She said NASA plans include:

A Gamma ray astronomy project which will measure the spatial and frequency distribution of very high energy photons.

An orbiting astronomical observatories project which will explore the region of the spectrum in which optical techniques can be employed.

An orbiting radio astronomy project which will provide observations of the longwave end of the spectrum.

GREAT LAKES AREA

(Continued from page 18)

Richmond, the Crosley Division of **Avco Mfg. Co.** is prime for *Weapon A* and turns out the stabilizer, missile container and flipper for *Falcon*.

Packard Mfg. Corp., Indianapolis, is making JATO parts for *Honest John* and in Columbus, **Cummings Engineering Co.** produces generator sets for *Nike* installations. Around Ft. Wayne, support equipment for *Nike* and *Bomarc* is being produced in quantity by the **Wayne Pump Co.** and **Farnsworth Electronics.**

The Magnavox Co., with a backlog of more than $50 million in military electronics devices, this year established an Anti-Submarine Warfare Department at Ft. Wayne. Its chief product is sonobuoys—developed over eight years of research, much of it in-house.

The Allison Division of General Motors at Indianapolis entered the rocket field several months ago and today is working on first- and second-stage motor cases for the *Minuteman* ICBM in a joint development program with **Thiokol.** And, recently, **P. R. Mallory & Co.,** at Indianapolis, formed a new electronics division oriented around missiles.

• **Boost for Ohio**—Of all the Great Lakes states, Ohio today appears to have the greatest single concentration of missile/space manufacturing. The big production centers are Akron, Cleveland and Dayton/Cincinnati.

Goodyear Aircraft, with sales running close to $100 million a year, is prime for the Navy's hot new ASW missile—*Subroc*—scheduled to be operational in about a year. The Akron company also has a multimillion-dollar contract for the *Nike-Zeus* AICBM Luneberg lens, is making radar antennas for *Hawk* and is handling logistic support for *Mace*. Another **Goodyear Tire & Rubber** subsidiary, **Goodyear Aviation Products,** also is in the missile support field—including carriers for *Atlas*.

Thompson Products Accessories, Cleveland, a division of **Thompson-Ramo-Wooldridge,** has the nose section for the Navy's *Bullpup*, the Army's *Pershing* transporter-erector, power drives for the Navy's *Terrier* and the pumps and fuel boost for *Hound Dog*.

Also at Cleveland, **Visioneering Co.** is making trailer undercarriages for *Nike-Hercules*. **Clevite Corp.** is fuzing *Bullpup* and **Willard Storage Battery** is making the batteries for *Falcon*.

Two of the Nation's leaders in the R&D of new metals are also in Ohio—**Mallory-Sharon** of Niles and **Brush Beryllium,** Cleveland. Brush is the developer of a 72-inch beryllium shield for the *Mercury* manned space capsule.

In the Dayton-Cincinnati area **Baldwin Piano** is fuzing *Sidewinder*, **Bendix Aviation** is building hydraulic equipment subassemblies for *Talos*, at Lockland **General Electric** is producing powerplants for the *Quail* decoy and **Aeronca,** Middletown, is working on a contract for *Jupiter* operational check-out shelters.

One of the Defense Department's largest R&D centers—the Wright Air Development Center of the AF Air Research and Development Command—at Dayton today is originating a continuous stream of work for companies across the country. On Sept. 1, WADC was administering 4003 active contracts totalling $100.5 million.

While no hub of private industrial development, WADC is itself a huge installation. More than 8300 persons—6700 of them scientists and engineers—are at work in 25 areas of technical research in laboratories sprawled over 1325 acres. The 200 buildings and their equipment are valued at $342 million.

In addition to contributing to the development of molecular electronics, WADC scientists recently came up with a high-acuity photographic system producing clearly defined pictures of the earth at 45,000 feet with a 1½-inch lens. The development, says WADC, suggests that a 36-inch lens 200 miles up in a satellite could achieve the same definition.

There is a 2700-man professional staff in the state's other major R&D facility—NASA's Lewis Research Center at Cleveland. The center's current budget is in excess of $27 million and there are plans to expand its facilities for studying chemical, nuclear and nuclear-electric rocket propulsion systems.

reviews

FATIGUE STRENGTHS OF AIRCRAFT MATERIALS. AXIAL-LOAD FATIGUE TESTS ON EDGE-NOTCHED SHEET SPECIMENS OF 2024-T3 AND 7075-T6 ALUMINUM ALLOYS AND OF SAE 4130 STEEL WITH NOTCH RADII OF 0.004 AND 0.070 INCH, H. J. Grover, W. S. Hyler and L. R. Jackson, Battelle Memorial Institute. Order NASA TN D-111 From National Aeronautics and Space Administration, Washington 5, D.C. 25p, $.25.

Results of axial-load fatigue tests on specimens described in the title, each having a theoretical stress-concentration of 4.0 are presented.

Tests were run at 0 and 20,000-psi nominal mean stress. The results extend those previously reported for tests on similar specimens and are compared with them.

EFFECTS OF CREEP STRESS ON PARTICULATE ALUMINUM-COPPER ALLOYS, E. E. Underwood and G. K. Manning, Battelle Memorial Institute. Order NASA TN D-109 from National Aeronautics and Space Administration, Washington 5, D.C. 62p. $1.75.

Particle dissolution, grain growth, and precipitation were studied under creep conditions in overaged alloys of aluminum with 1, 2, 3 and 4% copper.

With or without stress, particle dissolution is described by the same kinetic equation that applies to tempering and other phase transformations. The activation energy for dissolution in 3% copper alloys decreases from 70 kcal/mol without stress to 40 kcal/mol for a stress of 200 psi.

Relative activation energies for particle dissolution and grain growth coincide closely, suggesting that both are governed by the same process.

DEVELOPMENT OF NIOBIUM-BASE ALLOYS, R. T. Begley, Westinghouse Electric Corp. for WADC. Order PB 151739 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 192p. $3.

Included are results of studies on creep-rupture properties, flow and fracture characteristics, oxidation behavior, weldability, and purification techniques.

Flow and fracture experiments indicated that the ductile to brittle transition of niobium was little affected by the oxygen content in the range 0.01 to 0.1%. The impact transition range of electron-beam melted niobium was considerably below that of powder metallurgy niobium of somewhat higher oxygen concentration. An activation energy of 27,100 cal/mol was determined for strain aging in niobium.

Studies of the thermodynamics of niobium oxides and the kinetics of Nb-water vapor reaction showed that the thermodynamic functions obtained for the formation of Nb_2O_5 from Nb_2O were in agreement with the calculated values.

HIGH ENERGY RATE METAL FORMING, G. N. Rardin and others, Lockheed Aircraft Corp. for USAF. Order PB 151849 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 70 p. $1.75.

Tests performed during a three-month period to select the best method for explosive metal forming and to establish the quality of the product of the method are described.

Cupping tests confirmed that use of a shock focusing device is advantageous for increasing draw depth for air shots. Tests with a steel cupping die, with the air evacuated between die and work piece, and the explosive charge suspended above the work piece were inconclusive because the work pieces fractured before drawing to the full depth of the air.

Forming tests using plastic dies were satisfactory. Tests using a one-gallon paper container to support tap water as a transfer medium proved this size container too small.

Preliminary results using the cupping and beading dies in assembly with the bolster and tube, and a 24" column of water as the transfer medium, showed satisfactory performance with considerably less explosive weight.

• **Wood-Bridge, N.J.**—In a surprise move, **Curtiss-Wright Corp.** announced it is withdrawing from both Aerospace Industries Association and the Manufacturers Aircraft Association. C-W President Roy T. Hurley said his company is "convinced that the AIA and the MAA can no longer serve the defense program or the defense industry as is required to meet today's competition and have a healthy industry." C-W in 1958 paid $75,000 in dues to AIA, according to Hébert Committee testimony.

• **White Sands, N.M.**—The Army fired a test model of the *Nike-Zeus* AICBM for the first time here on Oct. 14 and reported that the shot was successful even though the bird fell short of its planned range, because it "yielded the desired technical data."

• **Salina, Kan.**—The first dispersed *Atlas* ICBM Squadron will be built here. Nine sites will be scattered over a 5500-square-mile area around Shilling AFB. One of them will be located not far from President Eisenhower's home town, Abilene.

• **Redlands, Calif.—Grand Central Rocket Co.** is embarking upon a multi-million-dollar expansion program coupled with a $2-million step-up in propellant R&D. Twelve new installations are planned with those required by the company's *Nike-Zeus* work getting top priority. Present employment of 600 is expected to double, perhaps triple. GCR says research will be aimed at developing and proving "a new class of high-performance propellants capable of delivering more specific impulse than has ever been obtained and to have them ready for application within the coming year."

• **Washington**—Sen. Stephen M. Young (D-Ohio) has demanded the complete unification of the armed forces and the expenditure of $2 billion to help the nation overtake Russia in the missile/space field. He said there was grave danger despite "a lot of soothing syrup" handed out by Defense Secretary Neil McElroy.

• **Washington**—The House Space Committee called for a "firm national program" to preserve U.S. know-how in boron fuel research. The committee said the nation has "a continuing requirement" for boron fuels for use in rockets and possibly ramjets (see p. 16).

• **Moscow**—Evgeny Fedorov, a top Soviet scientist, indicated Russia will continue its boycott of the U.N. Space Commission unless the Soviet Bloc is given as many votes as the West has in commission proceedings. The commission is seeking to reach international agreements on exploration of space. Fedorov also accused the U.S. of withholding space research data, specifically *Argus* results.

• **Cleveland**—NASA announced development of a prototype ion engine at its Lewis Research Center. It said plans for building larger models are underway.

• **Edwards AFB, Calif.**—A second full-scale **Boeing** *Minuteman* successfully roared from an underground silo. Nylon cables stopped the missile after it soared 500 feet.

• **Aberdeen Proving Grounds, Md.**—Army Secretary Wilber M. Brucker said the Army will seek a "large amount" of new money in FY 1960 for procurement of modern weapons—particularly missiles. He said the request would exceed the $1.7 billion the Army has for procurement of weapons in FY 1960.

• **Washington**—President Eisenhower renewed the Pentagon's right to keep secret from Congress and the public all military aid contracts. Congress has been bucking the President's refusal to disclose the contracts to congressional auditors.

Mergers & Expansions

With an eye toward developing specialized nuclear power systems, **Aerojet-General Corp.** is merging its turbo-machinery and nucleonics divisions . . . **Union Carbide Corp.** is building 25 million-pound capacity bisphenol-A plant at Marietta, Ohio. It will be ready in 1961 . . . Planned square footage of **Varian Associates** facility at Stanford Industrial Park, Calif., has been upped from 500,000 to 1 million . . . **Melpar Inc.**, Falls Church, Va., has just acquired five additional plants totalling 50,000 square feet for assembly of electronic devices . . . On the West Coast, **Electro-Pulse Inc.**, Culver City, has opened a new engineering division facility . . . and **Tamar Electronics Inc.** is in the process of building near Gardena, Calif., a 50,000-square-foot plant replete with a roof-top helioport and a swimming pool . . . At Woodside, N.Y. on Long Island, **Bulova Research and Development Laboratories** has fitted out an addition with $300,000 worth of new environmental and electronic test equipment to test missile warhead safety and arming systems.

Beryllium Extrusion Process Uses Glass

U-shaped beryllium extrusions 15 feet long and one-eighth of an inch thick have been produced by the **Norair Division** of **Northrop Corp.** The company is hoping shortly to produce 20-foot channels of the same thickness.

Norair is employing glass as a lubricant to guard against overheating when a billet is forced through dies at pressures up to 1700 tons and temperature of 2000°F.

Minuteman Rail System Bidders Now Total 20

Representatives of 20 firms have been briefed on railroad mobility requirements of the *Minuteman* ICBM by officials of **Boeing's Aero-Space Division.** Companies represented included: **ACF Industries Inc., Allis-Chalmers Mfg. Co., Baldwin-Lima Hamilton, Bethlehem Steel Co., The Budd Co., Chrysler Corp., Consolidated Western Steel (a division of U.S. Steel, Fairbanks, Morse & Co., Firestone Tire & Rubber Co., Food Machinery Corp., General American Transportation Corp., General Motors, Lockheed Aircraft, Magor Car Corp., Ortner Co., Pacific Car & Foundry, Pullman Standard Mfg. Co.,** and **Thrall Car Mfg. Co.**

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west coast industry . . .

By FRANK G. McGUIRE

Even zoning laws can throw a monkey wrench into a missile program—witness **Convair's** troubles at Kearney Mesa. The company has partially succeeded in its efforts to get a zoning change approved so that it can build a 300,000-square-foot, $4-million warehouse for storage of *Atlas* materiel and prefabricated parts. The change, although approved by the city Planning Commission in San Diego, holds some restrictions that Convair would like to have eliminated. The commission required street paving, water-main construction, and setback lines. Convair maintains this last provision would prevent it from building the Air Force-required security fence as specified. Convair pushed the change through the city council with an interim emergency zoning ordinance last month. The 24-acre site was needed, Convair said, or else the delay "might result in **Douglas Aircraft Co.** succeeding in its effort to get the additional *Atlas* work" which was required by the recent increase in *Atlas* squadrons. Douglas, however, has denied that it is negotiating for the additional *Atlas* work. Presuming City Council approves the final rezoning petition, the warehouse will be built by **Lessor Industries** and **Diversified Industries, Inc.**

Perkin-Elmer Corp. has opened a West Coast office . . .
in Los Angeles, and will complete its manufacturing facility here soon. The firm's sales for FY ending July 31 were a record $17.5 million, 16% over the preceding year. Heading the West Coast operation will be Leslie J. Cook, previously with **Thompson Ramo Wooldridge.**

"Made by the Bay for the USA . . ."
was considered as a label for the *Polaris* missile/submarine combination recently shown together for the first time at Mare Island Naval Shipyard. The launching of the USS Theodore Roosevelt (SSB(N)) brought the missile (full-scale model) and submarine together for the public, which marvelled at the small size of *Polaris* (28 feet). Prime contractor for the missile is **Lockheed**-Sunnyvale, propellant by **Aerojet**-Sacramento, and submarine nuclear reactor by **Westinghouse,** while the Navy's Mare Island Shipyard constructed the sub; hence all the major firms involved were located in the San Francisco Bay area.

Nomination for the best play on words . . .
in this Space Age goes to BMD's Astro News for its column heading of "The News Cone: Capsule Comments on Spatial Events."

Fabricel Division of Poly Industries . . .
fabricated the 20-inch-square aluminum paddles for *Explorer VI* in just three weeks under a contract from **STL.** The paddles, made of ultralightweight aluminum honeycomb, form the base for mounting of 8000 solar cells used to convert sunlight to electricity for charging the satellite's nickel-cadmium batteries.

Manned targets for aircraft rockets . . .
are being used by the Air Force at Holloman AFB, N.M. The **McDonnell** F-101B and the **Convair** F-106 are undergoing weapon system checks and adequate unmanned targets for them are not available. The rockets used are fired at a point ahead of the target plane, and would hit it if it continued on course. F-100's, F-102's and F-104's have been used as targets so far.

Sundstrand Turbo takes exception to the belief . . .
that turbine APU's were cancelled for *Atlas* because they were deficient in performance. Actually, the company says, the missile's design was frozen early, and AF was reluctant to make any design changes involved in a switchover from battery to APU systems.

letters

To the Editor:

There are two unfortunate errors of fact in the caption for the world's first industrial atom smasher that appeared on page 17 of the Sept. 14 issue.

The first error: "This is the world's first industrial atom smasher at Shippingport, . . ." This atom smasher is located at the atomic power department in nearby Forest Hills (our old Research Lab) and not in Shippingport. These two places are about 35 miles apart.

The second error: ". . . a direct industrial outgrowth of the atom bomb." This atom smasher preceded the atom bomb by seven years, having been dedicated in 1938 . . .

H. C. McDaniel, Director
Technical Information
Westinghouse Electric Corp.
Pittsburgh, Pa.

M/R apologizes for the mislabeling. The photo, printed as an illustration for the article on "How Missile/Space Spending Enriches the Peacetime Economy," actually is the Van de Graaff accelerator constructed in the late 1930's. Westinghouse has since replaced it with more modern equipment, including the testing reactor at Waltz Mill, Pa. The shell shown in the photo has been retained for its historical interest.—Ed.

NOT AT SHIPPINGPORT

WHEN AND WHERE

OCTOBER

American Standards Association, Tenth National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Oct. 20-22.

Society for Experimental Stress Analysis, 1959 Annual Meeting, Hotel Pick-Fort Shelby, Detroit, Oct. 21-23.

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

AFOSR/Mechanics Division, Aeronautical Sciences Directorate, WADC, ONR (host) AEC, ERDL, BUWEAP, BUSHIPS, NASA, Maritime Adm.: First International Symposium on Gas Lubricated Bearings, (An open meeting) Washington, D.C., Oct. 26-28.

Society of Photographic Scientists and Engineers, National Conference, Edgewater Beach Hotel, Chicago, Oct. 26-30.

Aircraft Electrical Society, Show and Convention, Pan-Pacific Auditorium, Los Angeles, Oct. 28-30.

Symposium on Space Age Chemistry, Cincinnati Section of American Chemical Society, Engineering Society Headquarters, Cincinnati, Oct. 29.

Institute of Radio Engineers, Professional Group on Electron Devices, Shoreham Hotel, Washington, D.C., Oct. 29-30.

NOVEMBER

Institute of Aeronautical Sciences, Annual National Midwestern Meeting, Wichita, Kan., Nov. 2-4.

The Combustion Institute, Western States Section, Fall Meeting: Equilibria and Performance of High Temperature Systems, Los Angeles, Nov. 2-5.

41st National Metal Exposition and Congress, International Amphitheatre, Chicago, Nov. 2-6.

Society for Nondestructive Testing, 19th Annual Convention, Hotel Hamilton, Chicago, Nov. 2-6.

Mid-American Electronics Conference, 11th Annual Meeting, Kansas City Municipal Auditorium and Hotel Muehlebach, Kansas City, Mo., Nov. 3-5.

Operations Research Society of America, 16th National Meeting, Huntington-Sheraton Hotel, Pasadena, Calif., Nov. 11-13.

American Rocket Society, 14th Annual Meeting, Sheraton-Park Hotel, Washington, D.C., Nov. 16-20.

Fifth International Automation Exposition and Congress, New York City, Nov. 16-20.

Instruments Division, Philips Electronics, Fifth Norelco Electron Microscope School, Hotel Victoria, New York City, Nov. 16-20.

Society of Aircraft Materials and Process Engineers (SAMPE) Eastern Division, Fall Meeting, Sheraton Carlton Hotel, Washington, D.C., Nov. 17.

The Institute of Radio Engineers, 1959 Northeast Electronics Research and Engineering Meeting, Boston, Nov. 17-19.

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Air Force Lays Down Space Policy

Speaking before a group of scientists in Boston recently, Brig. Gen. Homer Boushey, Director of Advanced Technology for the Air Force, established a few points of Air Force policy in the conduct of space exploration. Since the USAF was recently given a primary role in the field, they are of more than ordinary significance.

Space, he noted, is a location—and area—and not a project. As a medium it is indivisible with the atmosphere. There is no line of demarcation, nor is there one between aircraft and spacecraft. (An aircraft goes high, fast and far; a spacecraft goes higher, faster and farther).

Space should be used only when it can be used best, not because its use is more exotic. (It may be simpler, easier and cheaper, for instance, to lay more communications cables than to communicate via a satellite).

The general saw no conflict between the military and the scientist, and he could give many precedents for this feeling. Columbus was an admiral in the Spanish navy, but his voyages were not military. Admiral Byrd's work at the South Pole is a joint civilian-military effort. So was Capt. Cook's. So was the Lewis and Clark expedition. Space exploration probably will be the same and both the civilian scientist and the military man will profit.

The Air Force has definite ideas on the controversy over whether space should be investigated by men or machines and this is probably true of all the services. There is an old military maxim that nothing takes the place of personal reconnaissance. The USAF feels that man will find a useful role above the atmosphere as well as in it.

Gen. Boushey pointed out that man is a thinking animal; man is curious; man has judgment; man can contribute to reliability. For an investment of 165 pounds in weight, no machine yet devised can approach him in any of these respects. No machine can reason—nor be so fascinated by the unknown that it must go a little farther, a little higher, a little faster. No machine can have judgment when confronted by unforeseen emergencies. And no machine is as good as a man at replacing tubes or making adjustments in machinery.

Do We Like Being Second?

Emerging from an all-day meeting in Washington recently, the Science and Technology Committee of the Democratic Advisory Council proposed the establishment of a scientific laboratory or agency to work out the technical problems of maintaining world peace.

The suggested new agency, the Committee said, would act as a permanent laboratory for active study by recognized scientists of disarmament problems. These would include such areas as sending up satellites for nuclear inspection.

The Committee, which is composed of 17 scientists and engineers including two Nobel Prize winners, said that in the face of the enormous and highly dramatic challenge from the USRR, the United States has been given "intellectual tranquilizers" instead of intelligent action.

The Committee touched on the American space program only incidentally, listing it among the four items studied during the day-long meeting, but space matters tinged and weighted the report. Individual members spoke of the "enormous and dramatic challenge from Russia." They noted the "Soviet space probing successes." They said that *Sputnik 1* had given President Eisenhower a tremendous opportunity to awaken the nation to deficiencies in its educational system—but that he had failed to take advantage of it.

The voice of the Committee is just one more in a mounting chorus of conviction that our position as a poor second in the space race is due to the Administration's failure to regard the race as important.

An industrial scientist recently told a group: "My company intends to devote its time and money for the next year or so to research. There is no point in putting concrete proposals forward now." A military leader said: "I'm afraid we'll see little progress in the next 18 months, though this doesn't mean we shouldn't keep trying."

Where have we lost the vigor and the enthusiasm and the drive that brought the United States to world leadership? Where has the magic gone? The boldness? We talk in platitudes of the "technical approach," a cover-up phrase for timorous hesitation. We pinch a few pennies—pennies in terms of our national wealth—and watch the Russians soar ahead.

Is this really what the country wants?

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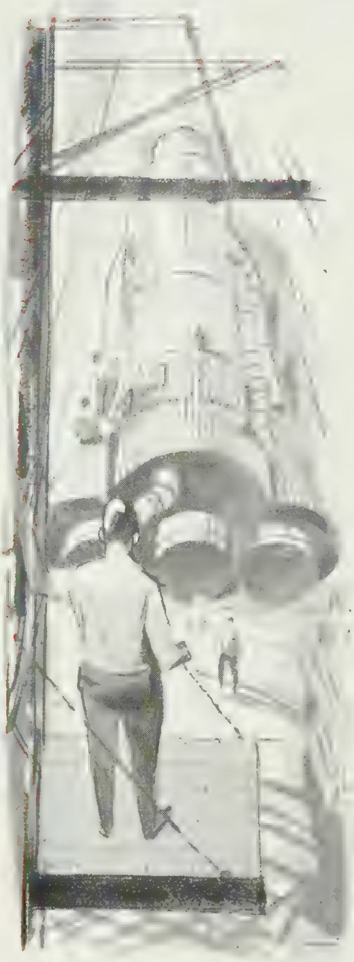

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Nike-Zeus—the Painful Choices . . . 18

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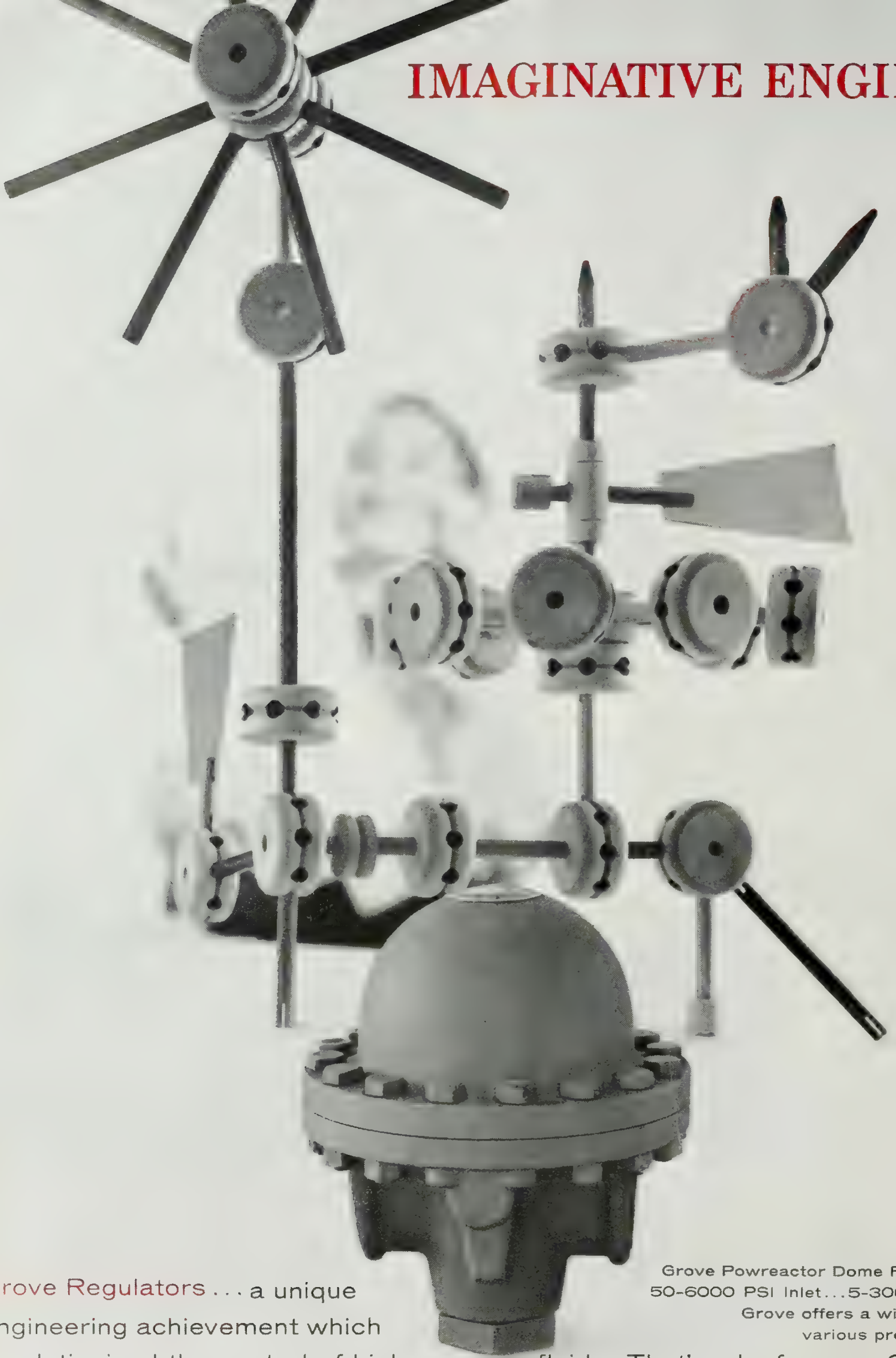

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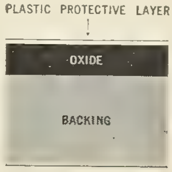

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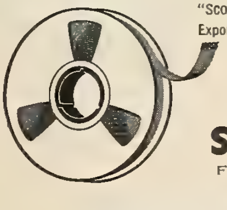

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Missiles and Rockets Volume 5 Number 44

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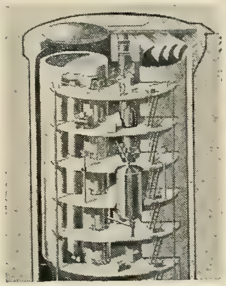
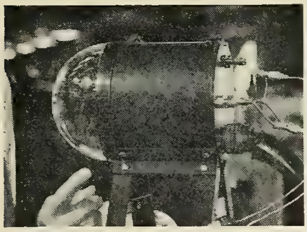
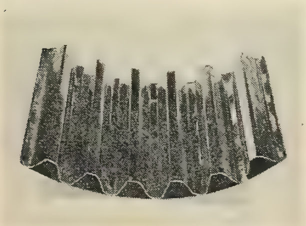
COVER: Scale model of space capsule is dropped in a water tank by scientists at NASA's Langley Research Center to simulate landing in ocean after flight.



UNDERGROUND launching facility for liquid-fueled ICBM is shown in artist's drawing. It calls for venting gases off at surface. An article on problems of ICBM launch bases begins on p. 21.



SIX-INCH diameter scanning head is a recent development in infrared airborne intercept equipment. A survey of the complex but promising IR market starts on p. 25.



MOLYBDENUM welds that can be flattened and recurved have been produced by Finn Aeronautical Division, providing unheard-of ductility for structural applications. See story on p. 40.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

31,000 copies of this issue printed

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Cold War strategy will dictate the White House choice of going ahead with the multi-billion-dollar AICBM program, trying to find a cheaper substitute, or doing without anti-missile defense .. 18

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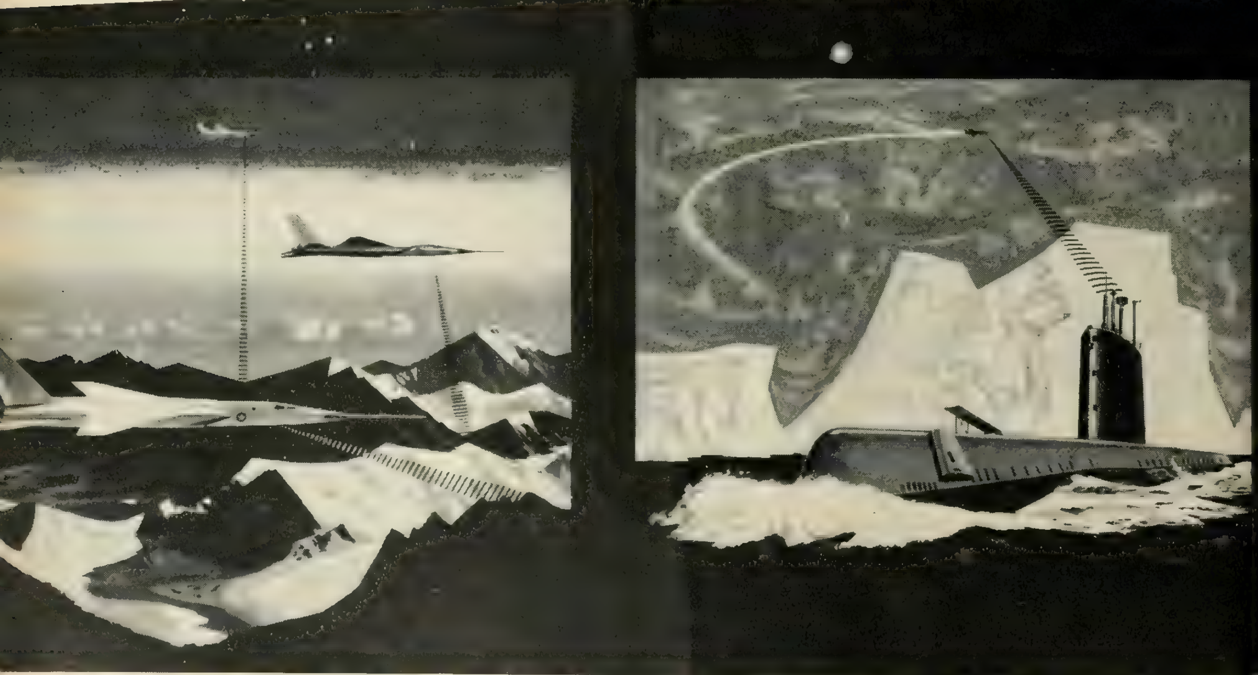

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Write Dept. 126

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- Missile control systems have been shrunk 70% in volume, 60% in weight, and designed for mechanized assembly.
- A missile launching silo was completely instrumented in two months.
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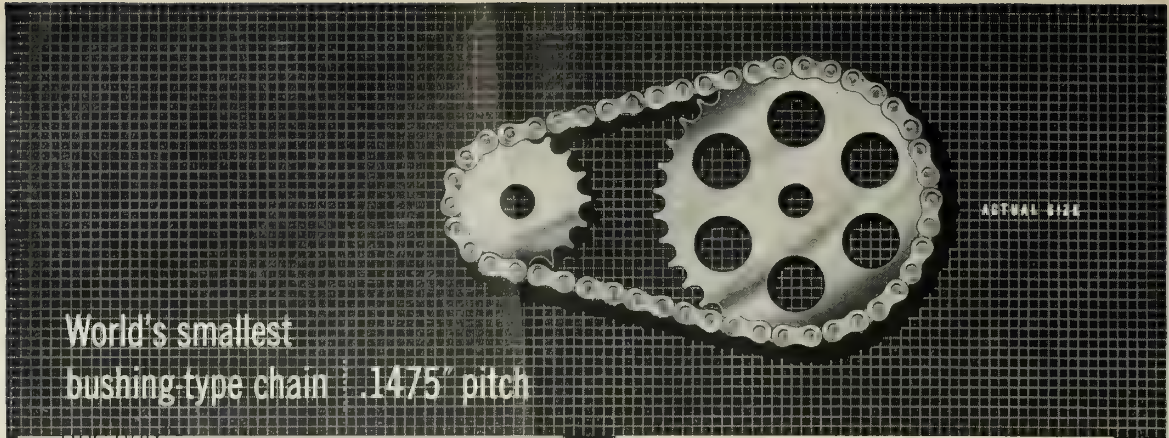

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NEW DIAMOND *Micropitch*

for miniature
and sub-miniature devices . . .

Precision-built of non-magnetic
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SPECIFICATIONS

Pitch	.1475"
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Weight per Foot (Approx.)	½ oz.
Chain length	+.051" to −.000/ft.
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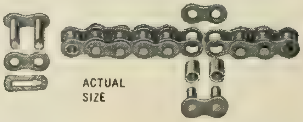
Tensile Strength	180 lbs. Average
Material	18-8 SS non-magnetic grade

Available also in ¼" Pitch, ASA No. 25 in stainless steel or standard steel.

SPROCKETS—Made to your specifications in regular or stainless steel, bronze, aluminum, nylon or other materials.



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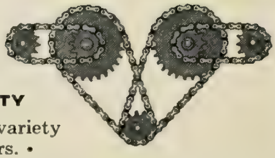

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when and where

OCTOBER

Armour Research Foundation, 15th Annual National Conference, Hotel Sherman, Chicago, Oct. 26-30.

AFOSR/Mechanics Division, Aeronautical Sciences Directorate, WADC, ONR (host) AEC, ERDL, BuWeap, BuShips, NASA, Maritime Adm. First International Symposium on Gas Lubricated Bearings, (An open Meeting) Washington, D.C., Oct. 26-28.

Society of Photographic Scientists and Engineers, National Conference, Edgewater Beach Hotel, Chicago, Oct. 26-30.

Aircraft Electrical Society, Show and Convention, Pan-Pacific Auditorium, Los Angeles, Oct. 28-30.

Symposium on Space Age Chemistry, Cincinnati Section of American Chemical Society, Engineering Society Headquarters, Cincinnati, Oct. 29.

Institute of Radio Engineers, Professional Group on Electron Devices, Shoreham Hotel, Washington, D.C., Oct. 29-30.

NOVEMBER

Institute of Aeronautical Sciences, Annual National Midwestern Meeting, Wichita, Kan., Nov. 2-4.

The Combustion Institute, Western States Section, Fall Meeting: Equilibria and Performance of High Temperature Systems, Los Angeles, Nov. 2-5.

41st National Metal Exposition and Congress, International Amphitheatre, Chicago, Nov. 2-6.

Society for Nondestructive Testing, 19th Annual Convention, Hotel Hamilton, Chicago, Nov. 2-6.

Mid-American Electronics Conference, 11th Annual Meeting, Kansas City Municipal Auditorium and Hotel Muehlebach, Kansas City, Mo., Nov. 3-5.

Institute of Radio Engineers, Fourth IRE Instrumentation Conference, Biltmore Hotel, Atlanta, Nov. 9-11.

Operations Research Society of America, 16th National Meeting, Huntington-Sheraton Hotel, Pasadena, Calif., Nov. 11-13.

University of Michigan, Fifth Annual Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Nov. 16-19.

American Rocket Society, 14th Annual Meeting, Sheraton-Park Hotel, Washington, D.C., Nov. 16-20.

Fifth International Automation Exposition and Congress, New York City, Nov. 16-20.

Instruments Division, Philips Electronics, Fifth Norelco Electron Microscope School, Hotel Victoria, New York City, Nov. 16-20.

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THE FIERY REALM OF THE ROCKET

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both structural and aerodynamic**

Smooth, strong rocket fin and nose cones made of R/M Pyrotex resist aerodynamic heat; have low, uniform ablation rate. The fin shown was subjected to tests at Mach 7.

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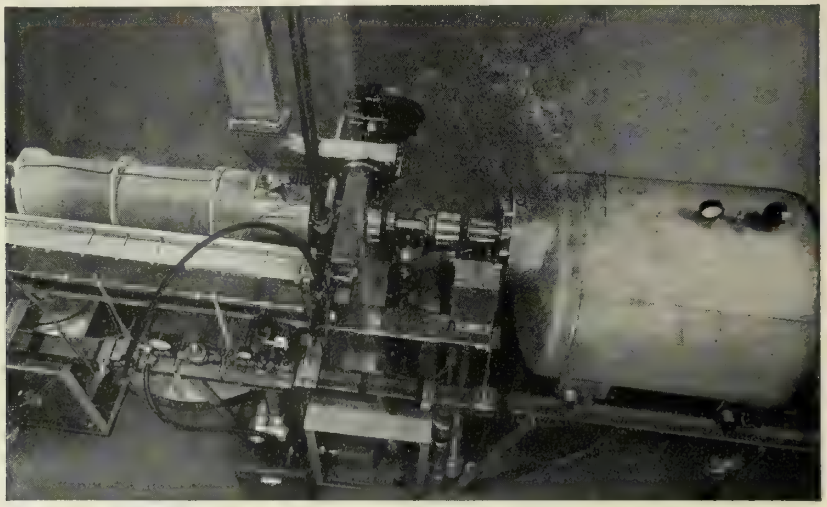
arco APPLIED RADIATION **news**

The first of a new generation of high power linear accelerators

High beam power at 10 Mev and beyond from ARCO L-band Linac



The ARCO L-band accelerator may be seen in actual operation at ARCO's Walnut Creek, California plant. Come and see it perform.

A new theoretical concept, developed by ARCO physicists, now proved beyond question.

First use of the lower L-band frequencies; higher power at lower cost.

A sweeping redesign of accelerating waveguide structures, radical with respect to conventional approaches.

Dependable Litton Industries L-band klystrons and other high-reliability production model components.

Accumulated experience of the world's largest designer-builder of electron linear accelerators.

Above are the basic ingredients which produced the new high energy, high power ARCO L-band linac—available now for unique experimentation or investigation, or practical, low cost per kw-hr radiation processing.

Data produced during exhaustive theoretical design and experimental testing on the first ARCO L-band machines are so conclusive that construction contracts in excess of $3,000,000 have been awarded for ARCO L-band accelerators.

A major advantage of the new machine is that it is not subject to the limitations (such as pulse shortening) in peak and average beam power levels that have plagued performance of earlier machines. Pulse shortening above the 4 kw level has been eliminated, despite output many times that of previous linacs. Performance of the new L-band machine shows that high power can be obtained even at energies up to 80 Mev.

Purchasers and engineers who have inspected the new ARCO machine believe it will usher in a completely new era in research and processing.

In research, the ARCO L-band machine makes possible exotic physics experiments such as neutron time-of-flight studies using flight paths up to ¼ mile in length. It greatly extends the range of experiments possible in single pulse radiation effects studies. It also permits measurement of transient effects in neutron multiplying assemblies.

In industrial processing, the higher performance and corresponding reduction in cost per kw-hr. are expected to make practical many applications which have looked promising in the laboratory but have been ruled out by high operating costs. Examples are polymerization processes, reforming of petroleum fractions, modification of polymers as in cross-linking, grafting and vulcanizing and commercial production of isotopes.

Data on the new ARCO L-band accelerator awaits your letter. Specific proposals appropriate to your application can be provided quickly and comprehensively. Your inquiry is invited.

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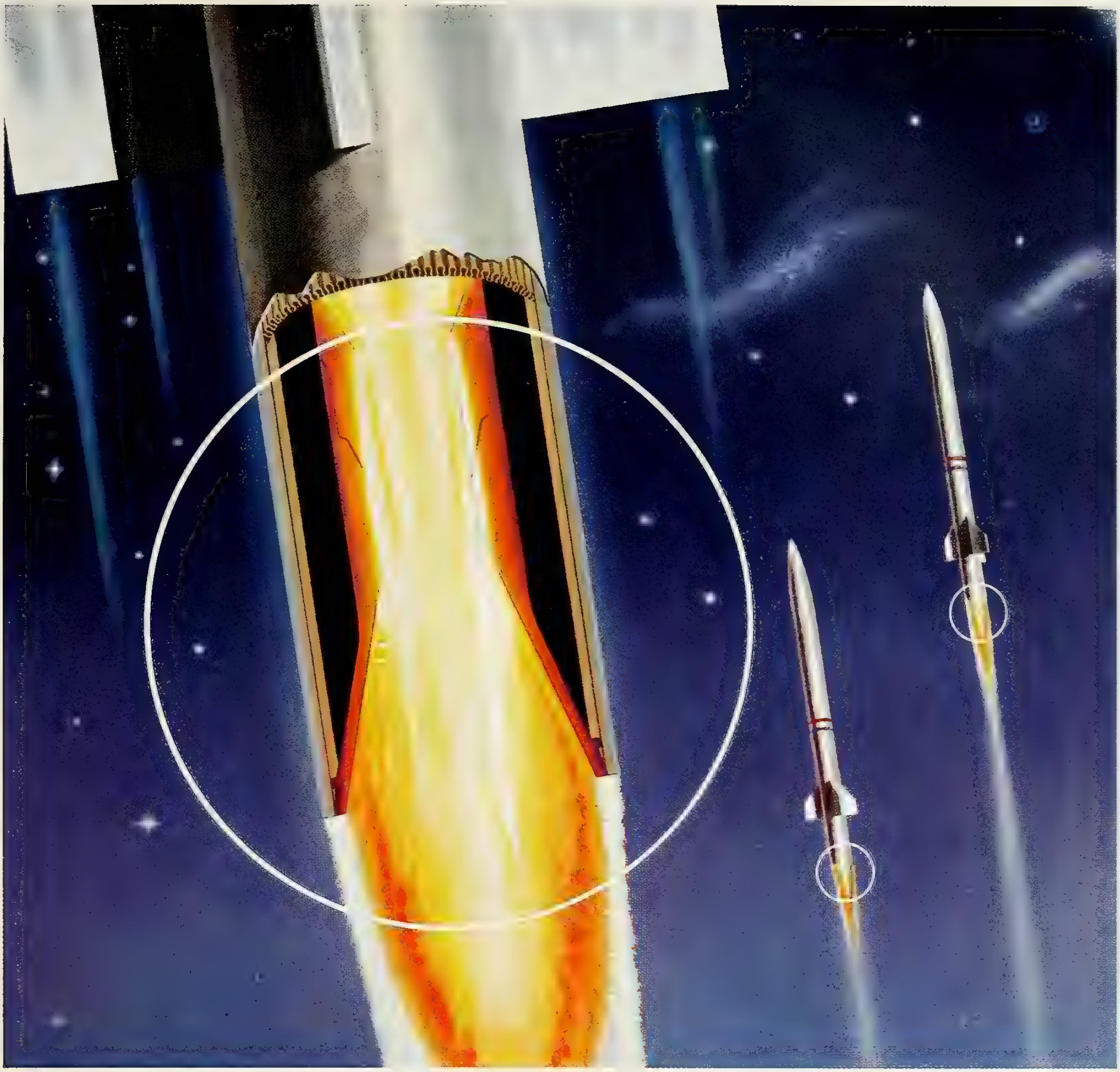

REFRACTORY MATERIAL FORGINGS FOR 5000° F TEMPERATURES

Cameron forgings have solved many a design problem, but this is one of which we are particularly proud. Nozzle throats in solid propellant missiles must control the fantastic temperatures which make high performance possible. All the push passes through this part and temperatures range over 5000° F almost instantly, but the throat insert must maintain its shape for peak burnout conditions. Just to complicate matters, the exotic alloys specified for these important parts are extremely brittle and expensive. In forming and machining the costly metal every ounce is important — with conventional processes fragility makes matters worse.

When Cameron's unique forging methods were applied to this unfortunate situation, some interesting things happened. Our years of experience in forging high stress, high temperature components helped change the picture completely.

Less material was required because our specially designed presses could forge to a near-final shape. Moreover, the ductility of these tricky alloys was increased, making them easier to handle and machine. As a result, we are now turning out quite a variety of our advanced forgings for nozzle throats to help give missiles the proper push.

Cameron forgings have opened many possibilities in advanced design today. Extreme service components for airframes, jet engines, guided missiles, nuclear power plants, and a wide range of other end uses are being forged by the Cameron split-die and down-acting presses.

If your design problem involves high stresses, high temperatures, or large, intricately shaped ferrous parts, maybe we can help. Just call, write, or come by . . .

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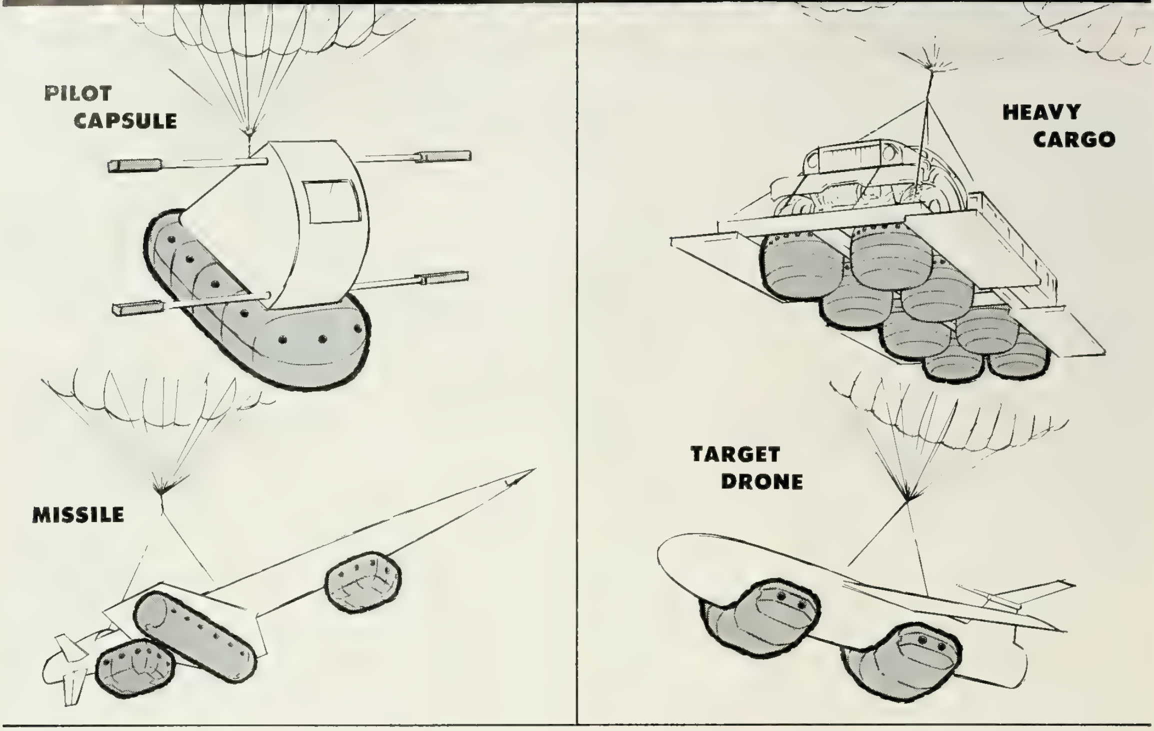
REFRACTORY MATERIALS: Molybdenum • Tungsten • Tantalum • Moly Tungsten • Tantalum Tungsten and others.

PNEUMATIC RECOVERY SYSTEMS / another product of Air Cruisers research



Solve New Missile and Capsule Recovery Problems

Air Cruisers has nearly a decade of experience in the development, testing and production of pneumatic recovery systems. Beginning with aerial cargo recovery, the company expanded its activities to include deceleration systems for various missile and target drone applications.

Other Air Cruisers system designs include recovery of missile nose cones and component parts, and pilot capsule recovery which enables the crew to land safely in the sealed capsule.

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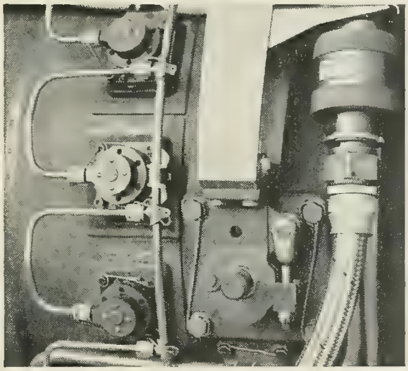
Aeroquip Quick-Disconnect Couplings and Hose Lines of Teflon Speed 'Hound Dog' Handling

Hound Dog, the Air Force's new air-to-surface nuclear-armed missile, lengthens and strengthens the retaliatory arm of the Strategic Air Command. Designed and manufactured by North American's Missile Division, the GAM—77 Hound Dog is equipped with Aeroquip Hose Lines of Teflon and Quick Disconnect Couplings. Used on its internal hydraulic system and on ground service checkout equipment, these Aeroquip products speed handling and checkout of system components.

As the leading designer and producer of fluid line products for aircraft/missile systems, Aeroquip can offer complete engineering and manufacturing facilities to meet your fluid system problems. Mail the coupon below for specific product information, or outline your problem to our sales engineering department.



Aeroquip Hose of Teflon with patented* ***"super gem"*** Reusable Fittings and 3200 Quick Disconnect Coupling shown here on the Hound Dog Missile, are also used on the external check-out system.

Aeroquip

REG. TRADEMARK

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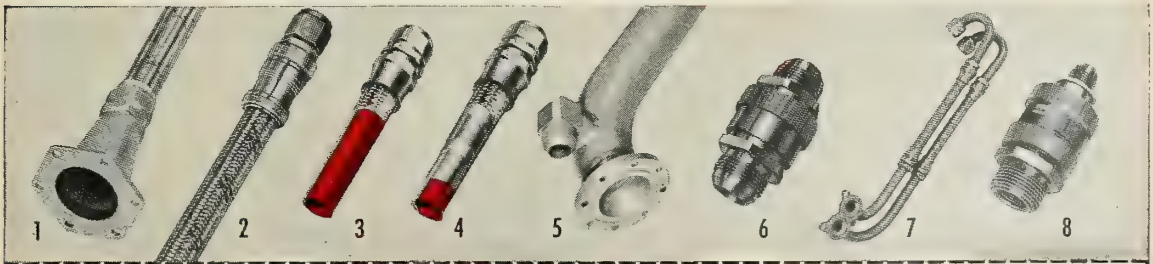

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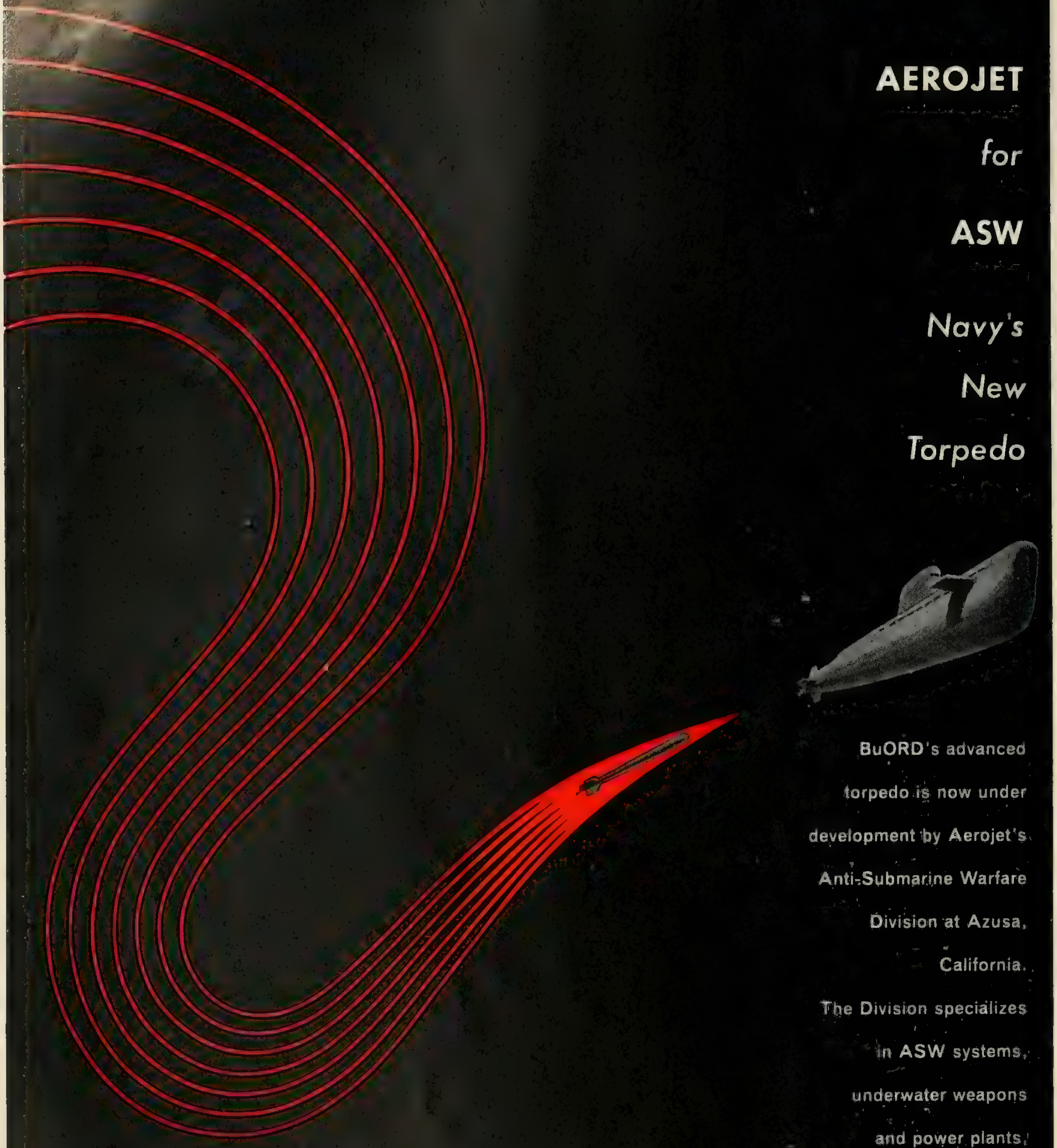
"super gem" is an Aeroquip trademark. *U.S. Patent Nos. 2,833,567 and 2,731,279. Teflon is DuPont's tradename for its tetrafluoroethylene resin



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for

ASW

Navy's New Torpedo

BuORD's advanced torpedo is now under development by Aerojet's Anti-Submarine Warfare Division at Azusa, California. The Division specializes in ASW systems, underwater weapons and power plants, hydrodynamics, and marine engineering.

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Industry Countdown

MANUFACTURING

Nike-Zeus may go underground . . .

in hard bases if the Eisenhower Administration decides to go ahead with production of the **Western Electric** anti-missile missile. (See p. 18) The AICBM would require a 15-foot diameter silo. Originally, it was planned to emplace *Zeus* on the surface, like conventional *Nike* sites. Hardening would add billions more to the missile's pricetag—already estimated at $9 billion to $14 billion, depending on the number of batteries.

• • •

Motor case problems . . .

reportedly are still plaguing the *Nike-Zeus* project. The Army is still trying to develop a case that is lighter and cheaper than the present prototype which is hand-tooled and costs around $25,000. **Grand Central Rocket** and **Olin Mathieson** are said to be offering Huntsville some new approaches.

• • •

Japan gets 14 *Sidewinders* . . .

from the U.S. this week—the first combat missiles to be deployed with the Japanese Defense Agency. This first shipment was delayed because of demand by other U.S. allies. Japan is hoping to obtain delivery of 90 more of the **GE-Philco** air-to-air missiles during FY 1960.

• • •

The Italian cruiser Garibaldi . . .

will be armed with U.S. *Terrier* anti-aircraft missiles. **Vitro Laboratories** is the systems engineering contractor.

• • •

How to beat Russia . . .

to putting a man on the moon? Here's a half-serious suggestion making the rounds of one rocket fuel company: pick three prime contractors with the most feasible approaches. Give each a drawing account of $100 million and complete freedom—no progress reports required. The first one to return with a bucket of moon dust wins $1 billion. After all, Lindbergh flew the Atlantic for a $25,000 prize.

PROPULSION

Second attempt . . .

to test the **Martin** *Titan* second-stage engine will be made next month at Cape Canaveral. Release clamps on the test stand malfunctioned Aug. 4, causing the big ICBM to blow up in the first try at second-stage separation and ignition. Despite the setback, Martin says the program is still on schedule.

• • •

Industry trend to plastic . . .

motor cases is gaining momentum. More and more designers are claiming reinforced plastic cases offer the best promise for short flight-time, high-performance missiles. **Aerojet-General,** with a $14 million plastics sales volume, believes that in five years 20% of its business will be in plastics—provided the potential of the material is developed properly.

ASTRIONICS

"Bonded" transistors . . .

are now being handled as carefully as 100-proof bourbon. Under a new "Meg-A-Life" program, **Motorola's Semiconductor Products Division** produces transistors to stiff MIL-standard specs and tests, all the while keeping them in bonded areas to assure use only in military equipment and to prevent intermixing of unchecked units.

• • •

$7.3 million Army . . .

contract has been awarded **Hughes Aircraft** to increase the company's "Missile Monitor" system capability for *Nike* and *Hawk* missiles.

WE HEAR THAT—

North American's B-70 . . .

is picking up some congressional support as a possible ALBM or boost-glide rocket launcher . . . **Rocketdyne's** 400,000-pound-thrust E-1 engine has been fired at least 25 times under regenerative cooling and a like number without cooling. Reportedly the engine works as well with storables (probably nitrogen tetroxide) as with conventional fuels . . . An education fund is underway in Minneapolis for the children of the pioneer balloonist M. Lee Lewis, killed last July . . . Engineering schools report a decrease for the second year in a row of undergraduate enrollments . . . **Ford Motor Co.** and **Coca Cola** are said to be among several big companies considering "orbital advertising"—using privately-owned satellites to beam taped commercials to earth.

Washington Countdown

IN THE PENTAGON

Twenty percent more range . . .

than previously announced is being built into the **Boeing** *Bomarc B*. The air-breathing surface-to-air missile is expected to have a range of more than 500 miles instead of 400. The range of the already-operational *Bomarc A* is less than half as much.

• • •

Extra cash for *Polarises* . . .

may come out of the Air Force's budget hide. The Navy is arguing that it should get a larger slice of the frozen defense budget at the Air Force's expense because the **Lockheed** *Polaris* system will soon be ready to take over some of the strategic targets that the Air Force has had to worry about.

• • •

The full *Saturn* timetable . . .

has almost been lost from sight in the current hullabaloo over the big program. Talk of operational dates such as 1962 or 1963 involves only the clustered 1.5-million-pound-thrust *Saturn* booster—not the three-stage *Saturn* vehicle that would be capable of lofting more than 15 tons into orbit.

• • •

Another year or two more . . .

is needed to develop the huge three-stage bird after the booster is operational. Even with a speed-up, that means a three-stage *Saturn* would not be operational before 1963 or 1964. Under the present program, it isn't expected to be ready to go to work before 1964 or 1965.

• • •

The new *Atlantis* . . .

is the Navy's latest program aimed at developing an underwater DEW Line for defense against missile-launching Soviet submarines. The goal is to spread an electronic screen hundreds of miles off U.S. coasts. Red subs could not pass through it without being detected.

• • •

Spacemen better beware . . .

of radiation caused by solar flares. Some scientists say it is a greater threat to space travel than the Van Allen radiation belts. New data shows that the sporadic solar flares increase radiation 10,000 to 100,000 times above normal.

The Douglas ALBM's future . . .

is being determined in the office of Pentagon R&E Boss Herbert York. The question: Should the almost-expired six month design study program be extended or should a big development program be started?

ON CAPITOL HILL

A new budget format . . .

is being pressed on the Pentagon by Congress, according to some reports. It would force the services to list their expenditures by function—particularly under the headings "limited war" and "total war."

• • •

A blueprint for battle . . .

is clearly seen in calling for such listings. By next June the advocates of more money for tactical missiles and other limited war forces are expected to be at the throats of the advocates of more money for ICBM's, *Polarises* and bombers.

AT NASA

Equatorial launch sites . . .

probably are headed for the scrap-basket. They are being done in by **Jet Propulsion Lab's** *Vega* and the "parking orbit" concept that it will make possible. By parking in orbit, the advanced rocket will be able to launch satellites and space probes into any orbit desired, thereby eliminating the need for specially-placed geographical sites.

• • •

Early obsolescence . . .

is expected to overtake the use of capsules in the exploration of space. The chances are good that the Project *Mercury* capsule will be rapidly replaced by winged space vehicles after the first manned space flights.

AROUND TOWN

Some of the reports . . .

being heard around the nation's capital:

. . . U.S. scientists are betting on a quantum jump soon in technology—possibly involving the secrets of gravity.

. . . One reason Russia is beating U.S. space efforts is that the Reds are concentrating on some 50 major space projects, the United States 150.

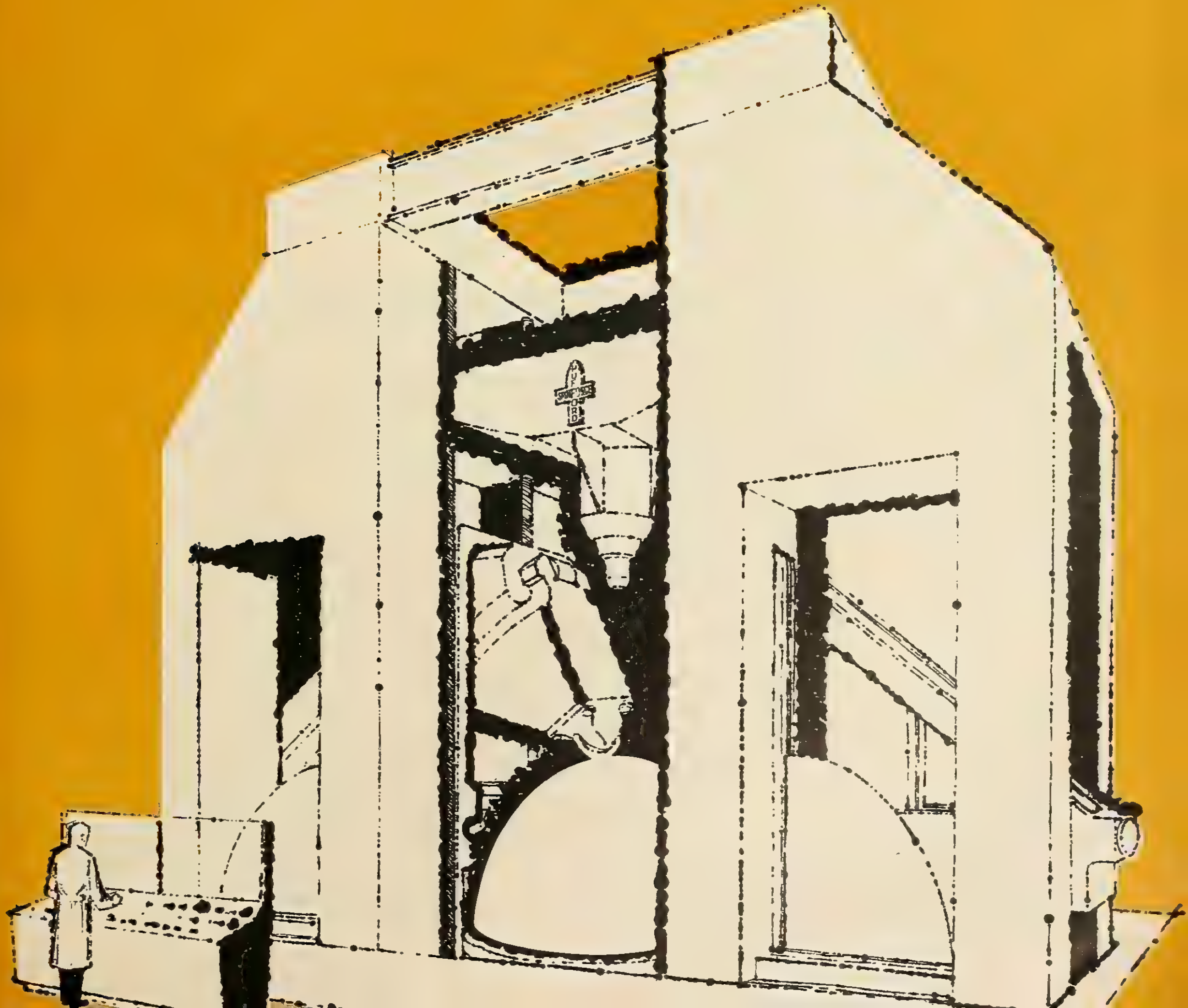
More About the Missile Week on Page 46

HUFFORD

A DIVISION OF THE **SIEGLER** CORPORATION

The Missiles and Space Division of Lockheed Aircraft Corporation has joined other leading missile manufacturers in selecting the Hufford Spin Forge. Largest machine tool of its type, the new giant will be capable of producing components as large as 8 feet in diameter and 20 feet in length...in conical, tubular, or parabolic shapes. Fully automated and immensely powerful (to 175,000 pounds vertical and horizontal roller force), it will form precision parts, of variable thickness to 1 inch, from toughest metals...in minutes. Only Hufford applies this new and important manufacturing process in such a dramatic range of products and with completely automated quantity precision. Only Hufford offers industry a complete Spin Forge development and production division. Let us assist you in the application of spin forging to speed your space age production. Write The Hufford Corporation, [illegible] E. Grand Avenue, El Segundo, California

WORLD'S LARGEST SPIN FORGE TO SPEED LOCKHEED SPACE AGE PRODUCTION



Expected by January . . .

Painful *Nike-Zeus* Choice Draws

by James Baar

WASHINGTON—The fateful decision on whether the United States will produce the *Nike-Zeus* anti-missile missile has come down to the basic question: How many bucks will we spend for the bangs?

The multibillion-dollar decision is of such paramount importance that it could:

- Rend the Eisenhower Administration in its final year and wreck its chances of coming up with a new balanced budget and a possible tax cut.
- Become a major factor in the 1960 presidential election campaign.
- Tip the life-or-death power balance in the Cold War.

Finally, because of the immense cost of *Zeus*, the decision will have a powerful effect on the nation's economy. More than 80 companies in 17 states from New York to California are taking part in the program.

Dr. Herbert York, Pentagon R&E Chief, is expected to complete drawing up his recommendations on the big **Western Electric** missile and pass them along to the Secretary of Defense and Joint Chiefs of Staff. The Defense Department is expected to make its decision by December.

• **Top-level headache** — Informed sources say that if the decision is to go ahead with production, the money to do it will have to come through an increase in the Administration-imposed $40-billion-dollar limit on the defense budget. Therefore, the final decision will have to be made by the White House.

On the other hand, any decision to kill *Zeus* or even to postpone production has such strategic and political ramifications that the final word is almost certain to come from the White House anyway.

Despite contrary reports, the final decision is expected before the first weeks in January, when the new budget will be sent to Congress. Any short-term further delay would force the Administration to announce its decision in the middle of a presidential election year—a politically risky business at best.

In essence, the Administration is faced with deciding whether to start a *Zeus* production program that is expected to cost anywhere from about $7 billion up, depending on how much protection the nation wants to buy.

The cost in FY 1961 alone will be about $1.5 to $2 billion. The cost then jumps to about $2 to $3 billion a year.

• **Time awasting**—Moreover, this decision must be made now if *Zeus* is to become operational on its present schedule—about early 1963. The schedule already is slipping week by week.

The reason for the current slippage is that the Defense Department and the Army are holding up spending $137 million voted by Congress for long leadtime items in order not to waste it if the decision goes against *Zeus*. A good share of this money is for the machines needed to produce electronic components for the *Zeus* system.

If *Zeus* is killed, the Army would spend the $137 million on its much-starved development and procurement programs for tactical missiles and other modern tactical weapons.

The fight over *Zeus*—the nation's only foreseeable anti-missile missile until the late 1960's at best—is far more involved with dollars, strategy and politics than with technology. To understand this, two points must be kept in mind:

- *Zeus* is primarily designed to defend SAC missile and bomber bases. It would give assurance that at least some of the nation's retaliatory forces not airborne in advance would live through an ICBM attack. Most experts concede that *Zeus* would be able to do this—at least until the Russians make their ICBM's more complex.
- *Zeus* is almost certain not to be used to defend large metropolitan areas, although some advocates of the program have proposed this, too. *Zeus*' value as a city defender is highly questionable; unlike a hardened ICBM base, a city is about as vulnerable to a near-miss by a nuclear warhead as it is to a direct hit.

Therefore, *Zeus* emerges as a costly protector of SAC retaliatory forces. The question is whether the United States can afford such a defense—or would the money be better invested in buying more ICBM's and bombers?

One rejoinder is that building more SAC bases still does not guarantee that any would survive. Another is that if the money isn't spent on *Zeus* there is a good chance on the basis of past performance that it won't be spent on anything else either.

• **More money a must**—This brings us to the money freeze, which is mak-

Reds Predict Two-couple Moon

WASHINGTON—Two eminent Russian scientists have predicted (according to a Soviet paper translated in Germany) that the USSR will send two men and two women around the moon for half a year next March or April. They admit there is little chance the four voyagers would return alive.

Published in the West for the first time on Oct. 1 by the Dusseldorf *Der Mittag*, the paper by Soviet scientists Evgeny K. Federov and Anatoly A. Blagonravov outlines a Russian space program which is both dynamic and ruthless.

The paper predicts that a Soviet satellite carrying two men will orbit the earth for 14 days by the end of this year.

Four weeks later, it says, two men with a TV camera will make a round trip flight to the moon, circling it twice.

In March or April next year, the two men and two women are predicted to make their sensational but almost certainly fatal trip. The Russians have some hope of picking the four up by a "Lunik Robot" rocket next September or October.

The timing of this shot coincides with the trip to the Soviet Union by President Eisenhower.

The scientists frankly state that lives will be lost in completion of these missions. "The base rockets," according to the paper, "will have no provisions for return to earth. A speaker for the Academy of Sciences pointed out that mankind must be ready to offer sacrifices for the privilege of exploring space, the moon and the planets."

"The first people who will be launched into space are fully aware of slight survival and return possibilities," the paper cautions.

Professor Federov is a geophysicist with the Soviet Academy of Sciences. A winner of two Lenin prizes, he was director of the Institute of Applied

Nearer

ing the Pentagon's dilemma all the more difficult.

The Army—low man in the defense budget—has no so-called "fat" whatever for diversion to a *Zeus* production program.

The Navy isn't in a much better position; nor is the Air Force.

Therefore, military men see an increase in the defense budget as the only way to buy *Zeus*. And such a move could mean that the Administration would have to throw away any possibility for a vote-getting tax cut and balanced budget. This does not make *Zeus* more attractive. However, the Administration also must face the politically unpalatable possibility that if it kills *Zeus* the program could become a juicy campaign issue.

In the end, the decision probably will have to be made mostly on the basis of national Cold War strategy. *Zeus* would buy the United States more safety in the dangerous years around 1963—the years of the Missile Gap. The question that must be answered is whether anything else would buy the time as well—and cheaper. Or whether the United States is willing to run the deadly gauntlet without either *Zeus* or a substitute.

Orbit in Spring

Geophysics of the Academy in 1955, and an executive of the Soviet IGY program for rockets and satellites in 1957. Professor Blagonravov is also a much-decorated scientist with the Academy of Sciences, and well-known to the West.

According to Federov and Blagonravov, the Russians have 200 well-trained crew members to carry out manned space projects.

Future Russian space achievements envisaged by the paper include:

- Rockets to Mars and Venus during 1961;
- Rockets to Mercury and Jupiter shortly thereafter;
- Manned ships carrying from two to six men to Mars and Venus;
- Large space "cruisers" carrying more than 100 people that will be assembled outside the earth's stratosphere from space stations, and which will be able to travel around the solar system. (No time schedule.)

Ion Rocket Can Shift Orbits

NASA experts suggest low-I_{sp} devices for switch from 300-mile to 24-hour level

BOSTON—Raising an earth satellite to a 14-hour orbit is likely to be one of the first tasks of an ion rocket.

J. Howard Childs and William R. Mickelson of the Lewis Research Center of the National Aeronautics and Space Administration at Cleveland have calculated that specific impulse values below 4000 seconds are ideal for such an application in terms of the time needed for raising the satellite.

They chose as an example the mission of raising a 6000-lb. satellite from a 300-mile circular orbit to the 24-hour orbit of 19,300 miles, 1° off circular. The analysis was presented at the **Avco**-Air Force symposium on Advanced Propulsion Concepts here earlier this month.

The best specific impulse for this application, they said, is determined by its effect on the rocket's efficiency and propellant consumption.

Grid electrode configurations were analyzed because of their simplicity, high efficiency and ease of replacement. High current densities are possible with moderate accelerating voltages. Thus high-voltage generators are not necessary.

In the case of such a satellite raising, the weight of the electric rocket necessary to adjust the orbit is quite small in comparison with the chemical rocket plus propellant that would otherwise be required.

The NASA experts said that the desired I_{sp} in this instance is below the range where the ion rocket attains its highest efficiency, but that such rockets still remained competitive.

• **Grid electrode erosion**—The assumption is first made that the satellite requires a 30-kilowatt power generating plant as part of the payload.

Ion impingement on the grid causes considerable erosion in a very short time. Unless this can be reduced to less than 1% of the ion flow, some scheme of replacing grid wires will be necessary.

The analysis showed that even with 1% of the ions impinging on the accelerating grid, this type of ion rocket still appears promising. The mass of wire material eroded is not large compared with the propellant consumed during the mission. If contamination of the ion source by sputtered grid material should prove damaging, tungsten wires could conceivably be used to eliminate the problem.

In some vacuum tubes, the ion impingement is approximately proportional to the grid area blockage. If it comes impractical to continuously replenish the grid wire coating as it is eroded, or if tungsten is used, then this amount of ion impingement could not be tolerated.

But, say Childs and Mickelson, the limited data available from vacuum tube experience provide a reasonable expectation that impingement of less than 1% can be attained through ion focusing.

Considerations of grid wire replenishment and energy losses associated with secondary electron omission point to a limiting voltage of about 2380 volts.

With this accelerating voltage and 1% ion impingement, the efficiency is about 67% at 2000 seconds I_{sp} and 82% at 3000 seconds I_{sp}.

These efficiencies give a raising time of 61 days at 2000 I_{sp} and 78 days at 3000 I_{sp} for the 6000-pound satellite.

It is not clear, the scientists said, that any other type of ion rocket configuration could yield efficiencies comparable to those of the grid electrode at low specific impulse.

If more sophisticated electrodes are employed, they will probably require a greater spacing and a larger accelerating voltage. This would result in excessive energy losses and sputtering erosion unless ion impingement of essentially zero could be obtained.

Childs and Mickelson said it appeared desirable to continue the development of grid-electrode ion rockets for propulsion of earth satellites in view of the favorable results of their analysis.

Hamburg, Genoa Weigh 640-Mile Rocket Mail

CUXHAVEN, GERMANY—The West German, Italian and French postal ministries are considering a proposal for establishing the world's first rocket mail service, between Hamburg, Germany and Genoa, Italy.

The Italian post ministry strongly supports the proposal. Delivery of mail over this 640-mile distance would take about 30 minutes.

Capt. G. Partel of the **Missile Systems Consulting Co.,** Rome, described the project at the international meeting of the German Rocket Society here last month. He said that if mail missiles could be scheduled hourly between the two cities, postage for a rocket letter would not be much more than that for a regular airmail letter.

The proposed mail missile is 13 feet long and weighs about 200 pounds. It can deliver a cargo of 750 to 1000 letters and postcards, weighing about 12 lbs. The missile is started with the aid of a booster rocket and continues its flight at an altitude of 8500 feet at a speed of Mach 2. Sustaining propulsion is on the ramjet principle.

Prior to landing, the missile is slowed by several braking rockets. Partel maintains his missile has guidance sufficiently accurate to land in a specified area not larger than its own length. At the destination point, the missile is turned around, refueled, provided with new cargo and a booster rocket and sent on another flight.

Italian postal authorities regard the new project as the first step toward the realization of a worldwide rocket-mail system, Partel declared. He said plans are being worked out to establish a central rocket postoffice in Europe for international rocket mail service.

The German society already is using rockets to deliver mail from the mainland to small islands in the North Sea. The first 10 were successful earlier this year and the society has begun mass production of mail-carrying rockets.

Space Materials Meeting Scheduled in Cincinnati

CINCINNATI—"Materials—Key to Space Flight" will be the theme of a national meeting here next April 27 and 28.

The Cincinnati, Dayton and Columbus chapters of the American Sociey for Metals will sponsor the program presenting a broad review of unclassified information on the unique demands made on materials by space flight systems.

The meeting also will include discussion of progress made to date in satisfying these demands and outlining of the unsolved problems that require intensive future efforts.

Speakers will be top technical experts from government and industrial organizations working in space flight technology. The program has been planned to cover the critical materials problems involved in launching, space flight and atmospheric re-entry.

Aerojet Pushing Hybrid Liquid-Solid Engines

SACRAMENTO—The **Aerojet-General Corp.** reports it has turned up some promising data in its studies of hybrid solid-liquid propellant rocket engine potentialities.

Aerojet said last week it has studied more than 200 possible fuel and oxidizer combinations and has found that some of them have very desirable specific impulse and impulse density values.

Aerojet hybrid engines are prepackaged combinations of liquid oxidizer and solid fuel, as in the diagram. To obtain maximum benefit from the system, the two should be hypergolic—that is, ignite spontaneously on contact.

The flow of oxidizer is controlled by a valve. This makes it possible to turn the engine on and off at will, just as with an all-liquid system. However, the use of solid fuel makes it possible to reduce the size considerably. A hybrid engine might have about half of the density advantage of a solid system. The size of a hybrid engine might be about halfway between that of solid and liquid for any given amount of thrust. However, Aerojet has not yet made detailed compactness studies.

Choice of fuels and oxidizers is limited, of course, by the availability of hypergolic combinations. Aerojet spokesmen declined to say what substances have been tested. Nor were any figures on impulse and density released.

(The Naval Ordnance Test Station at China Lake, Calif., reports it has attained a specific impulse between 255 and 265 seconds with a common nonaluminized double-base solid propellant and an ordinary halogenated oxidizer. It says calculations based on combinations designed especially for use in hybrid systems indicate impulses up to 365 seconds.

(Douglas D. Ordahl of NOTS did not limit his investigation to hypergolic combinations. Instead, he included a pyrotechnic igniter in his design.

(He said the only difficulty in using a hybrid system is the necessity to pressurize the oxidizer tank above the pressure of the combustion chamber.)

Cryogenics as oxidizers were not ruled out, even though the additional refrigerating gear adds more weight to a system. An Aerojet engineer said several members of the polyurethane family are hypergolic with liquid oxidizers.

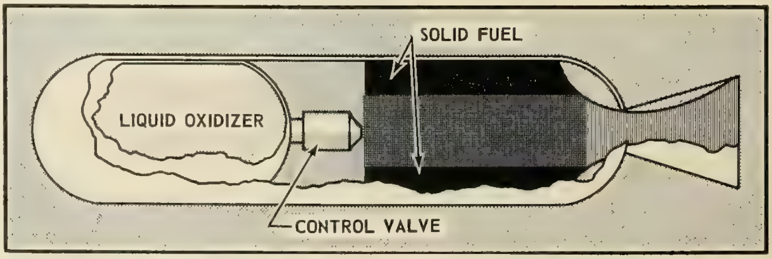
Some small-scale engines have been fired in the Aerojet program. More feasibility studies are in progress, particularly in the examination of various oxidizer-fuel combinations.

"Extensive performance analyses and optimization studies indicate that for many applications hybrid motors could be designed having distinct performance advantages compared with either solid or liquid engines," the company said.

"These analyses assume propellant availability above certain specific impulse and density values . . . It was found that some . . . systems possess exceeding desirable specific impulse and density impulse values.

"These facts have renewed our interest in the hybrid motor; we feel extensive studies are warranted to determine the practicability of the calculated system and to reduce some of the design concepts to practice. It is expected that within a year substantial additional data will be available to support the potential of such a powerplant."

Aerojet, a subsidiary of the **General Tire & Rubber Co.,** said it was conducting the studies entirely with company funds.



HYBRID ENGINE: Control valve sprays liquid oxidizer across solid fuel.

Launching: Where ICBM's Are Weak

'Mix' of hard, mobile and dispersed sites needed to escape enemy missiles; new design for 'hard' Titan base

by Warren R. Stumpe*

GREENWICH, CONN. — Launching techniques for ICBM's are a military operational-analysis problem. Today the trend appears to be from soft to hard to harder to hardest to mobility and dispersion.

No one launching technique necessarily is better than another. Rather, just as any good team mixes its plays, we need a good mixture of all the launching techniques to confuse the enemy. The problem becomes, therefore, not so much one of absolute cost, as cost per retaliatory missile launched after an initial enemy attack.

The launching problem for retaliatory ICBM's is quite simple to state, but quite difficult to achieve. The weapon must be relatively immune to an initial salvo of enemy missiles carrying nuclear warheads and still be capable of retaliatory firings within a specified minimum time.

For this discussion a "soft" launching site is defined as one basically not designed to withstand the blast, ground shock, heat or radiation effects of a nuclear or thermonuclear explosion. A "hard" launching site is designed to withstand these effects for a specific warhead megaton yield and within a specified overpressure. Now, let's look at today's ICBM's and see how well they meet our launching criteria.

- **Hard *Atlas* base concept**—Present *Atlas* bases are above ground. The 75-foot high, 10-foot diameter missile, weighing 243,000 pounds is stored horizontally in an unfueled condition. For launching it is raised to the vertical position by an overhead erector, fueled and fired.

Good design of the sliding roof, erector, and fueling system achieves the required minimal response time. While not meeting requirements of a hard site, the unusually large quantities of reinforcing steel used in concrete construction do provide some blast resistance.

RAIL SYSTEM for *Minuteman* is shown in model conceived by AMF and ACF. Some 20 firms are bidding for the system.

Since megaton warhead yields are becoming larger, the enemy can be a considerable distance off-target and yet damage the installation. In order to overcome this deficiency, a new underground launcher design, similar in concept to the *Titan* launching system described below, is now on the drawing boards at **American Machine & Foundry Co.** and at the **Bechtel Corp.** under the direction of **Convair-Astronautics.**

Like the *Atlas, Titan* is liquid-fueled. The *Titan* is 90 feet long, 10 feet in diameter and weighs 222,000 pounds fully fueled. It will be stored, serviced, and launched from completely contained underground installations.

This is the first missile installation that can be justifiably designated as hard, since it is designed to operate in a high overpressure range against a high megaton warhead yield.

In the silo, the *Titan* missile is placed by stages onto the launcher platform, which operates as an elevator. When the first stage is loaded above ground, the launcher platform is lowered so the second stage can be installed at ground level; and lastly, the nose cone is similarly installed. The fully assembled missile, when lowered with the concrete doors closed, is in the *hard* condition.

Needless to say, data describing the effects of nuclear or thermonuclear explosions, in regard to blast and ground shock are not abundant. AMF, as the launcher system contractor on the *Titan* program, was contracted by the Air Force to define the effects of the nuclear explosion. This resulted in an Architectural Engineering Handbook available to both the A&E contractor for his installation design and to AMF for the launcher design.

In the hard condition, the missile is isolated by means of a crib structure which is shock-mounted through a mechanical spring system. Within this crib structure, the missile is raised and lowered on the launcher platform. When the command to launch is received, the crib is locked to the silo walls, the missile is fueled, the doors are opened, and the missile raised to the firing-position.

It is obvious that the *Titan* approaches our initial criteria of installation protection and minimum retaliatory time. It should also be noted that in addition to the missile itself, all the ancillary parts of the weapon system must also have the same hardness capacity.

A missile complex involves three missile silos, 155 feet deep and 40 feet in diameter; three propellant silos 37½ feet in diameter; three equipment silos 50 feet deep and 40 feet in diameter; two antenna silos 65 feet deep and 27 feet in diameter in addition to a control center. All of these underground installations are interconnected by tunnels 6 to 10 feet.

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* *A graduate of West Point and Cornell, Mr. Stumpe is manager of American Machine & Foundry's mechanical laboratory.*

Of course, since they are self contained, they must be fully air-conditioned and provide the necessary living quarters.

It is obvious that the actual costs of hard installations are substantial, but the actual cost of retaliation, based upon war gaming, may be lowered. Just as *Atlas* has now adapted the *Titan*-type hard system, *Titan* is now being studied for an in-silo-type launching complex similar to that of the *Minuteman* by which the missile is launched from below ground. (See illustration.)

• **Silo launch testing**—The *Minuteman* ICBM weapon departs radically from *Atlas* and *Titan* in concept and operation. *Minuteman* was conceived as a relatively inexpensive weapon system. Since it is a solid propellant weapon, it has some definite operational advantages over the liquid fueled *Atlas* and *Titan*. Its warhead capacity, however, is smaller than either *Atlas* or *Titan* and therefore the need for these ICBM systems for selected targets will remain.

The *Minuteman* operational concept is quite simple. Many missiles will be stored in underground silos similar to *Titan*. However, because of the solid propellant, and other system improvements, *Minuteman* can be stored underground for long periods with minimum service requirements. On the command to launch, doors will be opened and the missile launched directly from the underground position.

The advantages of this system are obvious from an operational point of view. The missile remains in the hard condition for the maximum amount of time prior to launch. In addition, the improved reliability achieved by eliminating those mechanisms required to bring the missile to the surface is definitely worthwhile.

Titan launching from a below-ground position, would be improved in reliability enough to warrant the change, even if no economic benefits were accrued.

The engineering problems of a below-ground launch are substantial. Today, test programs are going on at Edwards Air Force Base to determine the effects of such a launch. The acoustical problem of reducing the contained noise level to a value at which the missile itself is not damaged by the resonances is a substantial one, as is the handling of the exhaust gases of combustion.

• **The future?**—With weapons such as *Atlas, Titan,* and *Minuteman,* the United States has the capability of massive retaliation with minimum reaction time. The problem is simply how to protect these weapons from a surprise attack since we are committed never to launch the first blow. We've talked about hardness, but that is still a relative term depending upon the megaton yield and the overpressure. The question really is "How *hard* is *hard?*"

As megaton yields become larger for similar size warheads, is our present hard criteria becoming obsolete? Can the enemy damage our retaliatory capability by using larger megaton warheads within present accuracies or even with less accuracy? This answer is probably yes. When we talk about the affect of a multi-megaton bomb, we are talking about craters several miles in diameter and ½ mile deep.

The problem of putting in a hard installation against this type of attack is enormous. It can be done through such methods as installations within mountains, or underwater launching sites, but several of these types of installations could easily use up a good portion of the yearly defense budget. In addition, there is already arising criticism in some quarters against fixed bases as a "Maginot Line" philosophy. The answer—if fixed bases will not suffice, we must consider mobility and dispersal.

• **Mobility**—The problems associated with the mobility of inter-continental missile sizes are considerable. Essential characteristics of inter-continental missiles for mobility requirements are that the missile contain a power plant or thrust package which will permit minimum reaction time for the weapons system. Also, the trend for more efficient power packages is producing missile configurations and characteristics which are more adaptable to mobile launching than the present liquid fueled missile. Pre-packaged fueled missiles may, however, satisfy the operational requirements for mobility.

As the circular probable error of future enemy weapon systems decreases, launcher system mobility and dispersal may become an essential requirement for the survival of our deterrent missile forces.

• **Types of mobility**—There are three types of mobility, namely, air, sea and land. In air and sea, we are already developing a capability with the air launched ballistic missile being developed by **Douglas** and the *Polaris* submarine launched ballistic missile by **Lockheed.** Land mobility is an area relatively untouched to date for ICBM size missiles. Recent articles have indicated that *Minuteman* is being considered for a mobile system to supplement the fixed installation. There are three basic types of land mobility—railway, on our vast railroad network, vehicular, on improved roads or cross country, and inland waterways, on our navigable rivers and lakes. While the latter may be thought to be closer to sea mobility, since it is within the continental United States, it is included as land mobility.

• Railway—American Machine & Foundry Company, in conjunction with **American Car & Foundry Company,** has recently completed a thorough study of the railroad mobility problem for an inter-continental missile size. There are ¼ million miles of main-line railroad within the United States. It is AMF and ACF's belief that rail-borne launching systems provide exceptional capabilities for mobility and dispersion in relation to overall system cost.

It is expected that costs for railroad missile support systems may be considerably less than for competing hard based systems. The operational philosophy would be quite simple. Many missile car complexes would be kept in almost continual motion. Numerous launch areas could be surveyed along railroad right-of-ways. When the launch command is received, the missile car would proceed to the closest launch area and fire the missile.

The problem is, of course, that a ballistic missile must be accurately launched if it is to hit a target, hence the need for surveyed predetermined launch areas. The simplest way would be to launch the missile directly from the car, although separate launch pads are also a possibility. Of course, there must be a number of ancillary cars in the missile car complex to provide the required services and accommodations.

• Vehicle—Vehicular mobility is also a definite capacity. Whereas railroad mobility can be achieved utilizing standard railroad equipment, vehicular mobility poses a somewhat different problem. The vehicles needed for a complete system would be numerous and somewhat large for an ICBM size.

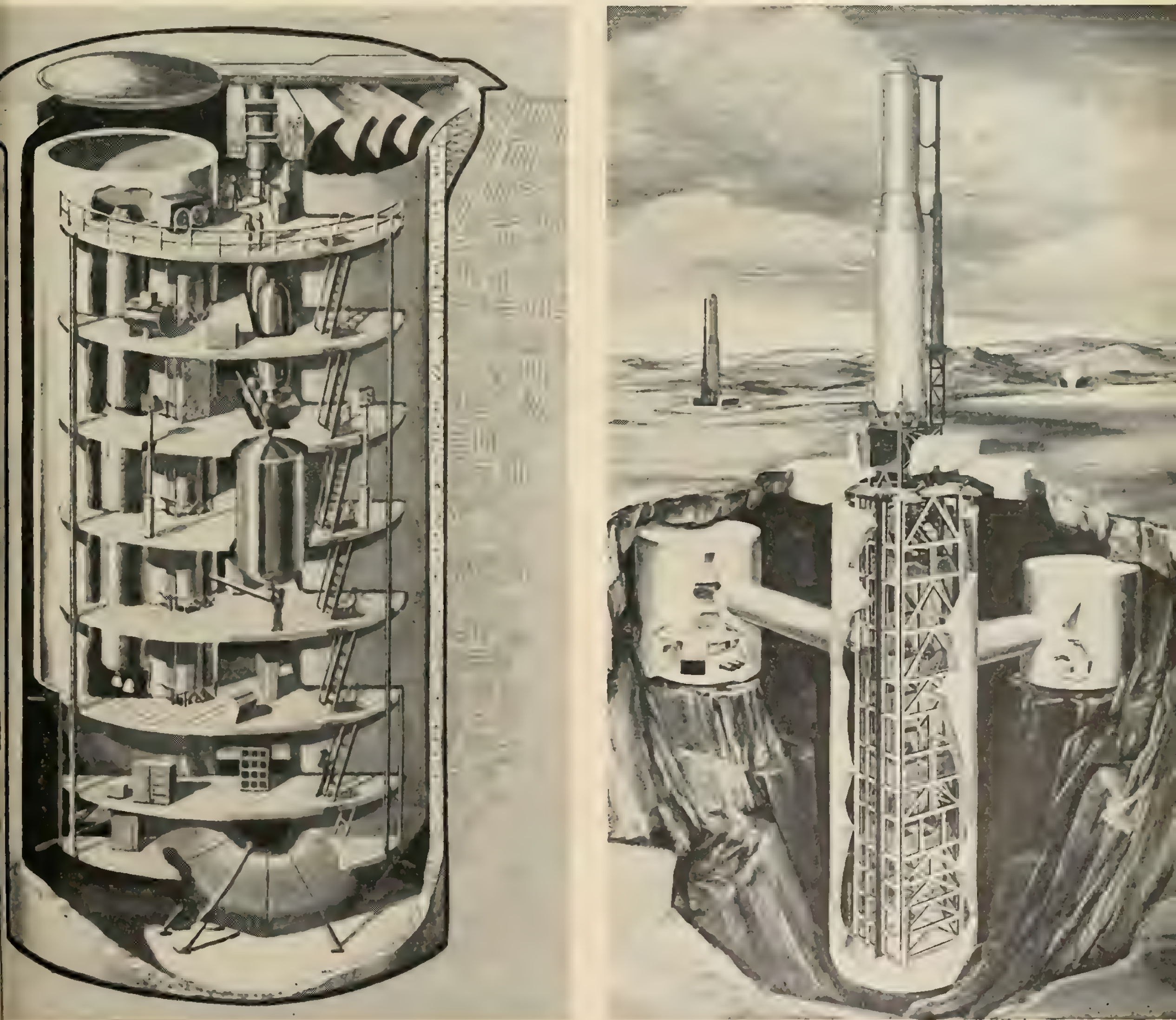
This would make over-the-road travel undesirable as it would require special escorting, load surveying and routing. It would, therefore, seem to be more desirable to use cross country travel utilizing the 400 million acres of land still in the public domain. There are many areas of this country in that category with sparse populations and little or no natural obstacles to impede a convoy of this type. This system might operate by continual rotation between several fixed soft launching sites. It would be difficult, if not impossible, to predict where the missile was at any particular time.

- Waterway—The thousands of miles of navigable waterways offer still another type of mobility. Here the missile system could be contained in a single barge or Great Lakes steamer. It, too, could be kept in continual motion so that prediction of its location would become difficult. Its prime disadvantage is the slow speeds attainable so that if it is spotted and reported, it might be still within blast zone of an enemy missile launched.

- Integrated Mobility — Mobility with dispersion may offer an answer to the ultimate hardness problem. We call it "Integrated Mobility" in AMF; that is, a good balance of all types of land mobility—rail, vehicular and waterway. Its concept is based on the premise that specific areas of the country can support more than one type of mobility dispersal technique.

Much land suitable for vehicular overland mobility also comes in contact with the railroad systems and navigable waterways. In these areas, a higher mobility potential can be achieved if all the techniques are integrated. It may even be feasible to transfer missiles between systems—overland to railroad to overland, as an example. The "piggy-back" type of operation is a proven system and it combines the long-haul efficiency of the railroad with the short-haul flexibility of the road vehicle.

The ultimate in mobility (if, indeed, there is an ultimate) will be the ultization of all mobility approaches. Launchings will be possible from railway cars, overland vehicles, inland waterway vessels, ships at sea, submarines, and conventional aircraft. Nuclear powered aircraft, that can stay aloft indefinitely and space platforms will add a new dimension to the mobility area, and perhaps will then achieve the ultimate in mobility.



UNDERGROUND LAUNCHING concept for liquid-fueled missiles is shown in artist's drawing at left. It would allow for firing the missile from the silo, with gases vented off at surface. *Titan* launching site of type now being built at Lowry AFB is shown in drawing at right. Bird is stored underground but must be raised to surface for firing.

SIGNIFICANCE

Much of United Aircraft Corporation's success may be attributed to its ability to determine the genuinely significant areas of technology before committing valuable talent and resources.

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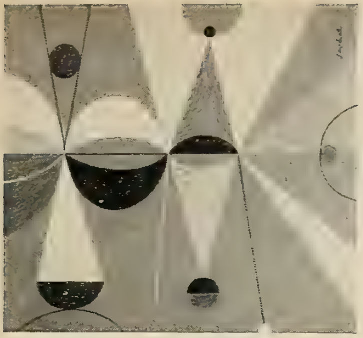

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Reply to Mr. John North
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Billion-dollar Market Seen for IR Industry

Future expansion rate depends on research breakthroughs and product development

by Charles D. LaFond

WASHINGTON—The infrared industry is growing like an adolescent pup. Just now learning its own strength, it is rapidly becoming a major contestant at the electronics-market feedbowls, successfully snatching large chunks from several dishes heretofore dominated by its more mature cousins.

It is a most unusual field. Leaders in the industry are not even roughly consistent in describing the market picture. But they agree to one premise: The infrared market—and this includes both research and development plus hardware—has only barely been tapped. Its strength is apparently based on the compatibility between commercial and military IR developments which result in broad applications with every breakthrough.

• **Market today**—Estimates of the total market for fiscal 1960, including associated R&D and hardware, range from $300-500 million. Total defense market appears to be in the range of from $115-125 million. A very large portion of this total represents DOD research dollars.

The defense expenditures in the IR field may be considerably higher. Stringent security classifications applied to these government R&D and hardware contracts make it very difficult to obtain complete figures. Estimates are further confused because of the inclusion of such things as electronic amplifiers and data handling equipment, produced by the same manufacturers. Other totals often are buried in other military R&D budgets.

Also, while many IR-device designs are firm, the future is clouded because of the uncertainty associated with many missile and aircraft programs.

• **Review**—Infrared radiation is electromagnetic radiation. In the electromagnetic spectrum, it ranges in wavelength from 0.7 to 1000 microns. Thus it falls between the areas of visible light and the radar wavelengths.

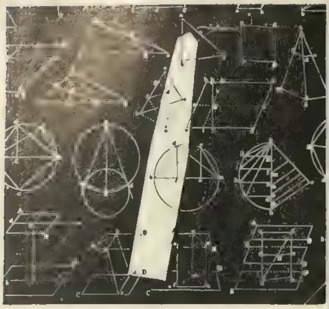
All objects emit IR radiation which varies with the temperature above absolute zero. The emissions are broadband and, as temperature increases, peak radiation occurs at decreasing wavelengths. The molecular thermal characteristics of the object determines its emissivity. This emissivity factor determines maximum IR radiation at any given temperature for each object.

The IR radiation can be collected and focused optically or it can be transmitted through certain opaque materials, such as germanium and silicone. Using a suitable photoelectronic detector the energy can then be electronically utilized, depending on the particular application.

The physics of infrared technology have been known for years, yet it was not until World War II that any real progress was made in the exploitation of IR radiation. This was due largely to the lack of suitable detectors originally, but later it was simply a failure to recognize the vast potential.

By the time this country began to invest in limited IR research, others had given their programs a high priority. As early as 1944, the German Air Force was in final development stages for the use of IR homing devices in guided missiles. When the war ended, these missiles were awaiting field tests. They also had developed successful applications of infrared to airborne and ground search and tracking systems, proximity fuses, and temperature mapping.

• **IR leaders**—As might be expected, most of the electronics systems leaders have a strong investment in the infrared field. Many have come in late, but



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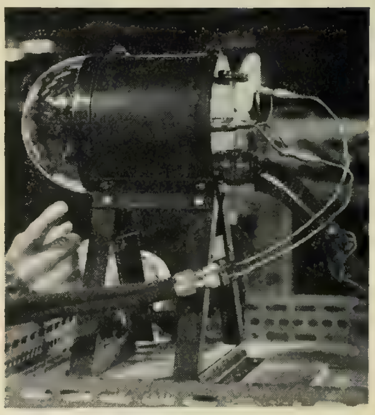
A few of the developments . . .

THERMICON thermal imaging tube being developed by Westinghouse for track-while-scan, multiple target handling.



PORTION OF an IR airborne intercept system, this six-inch diameter scanning head weighs only 10 pounds.

the possibilities are so great that almost any interested company can find an area through which it can enter the field and progress.

The Avionics Division of **Aerojet-General Corporation** is one of the oldest and largest firms in the IR industry. According to R. W. Powell, new division manager, his organization has completed more different military IR hardware programs than any other company. Currently, the division is carrying a minimum of $10 million of this part of the market. Powell pointed out, however, that this figure may be low. Sixty percent of the available funds (military hardware) is allocated for the production of just a few systems and Aerojet is a major contributor to each, he said.

The division has employed IR techniques in military equipment such as: missile seekers for terminal guidance; surface and surface-to-air fire control devices for target detection and tracking; aircraft defense equipment; attitude references and satellite horizon scanners; search gear for warning, acquisition, or collision avoidance; radiometers, and spectrometers for target radiation profiles or for field data-recording. It also produces IR accessories and test and checkout devices.

Philco Corporation is currently producing IR detection systems, new types of highly sensitive detector cells, and cryostats for cell cooling. The company has under development a family of mosaic detectors—linear arrays and rectangular configurations.

And, of course, the company has been a major contributor to the field with its infrared-homing *Sidewinder* air-to-air missile.

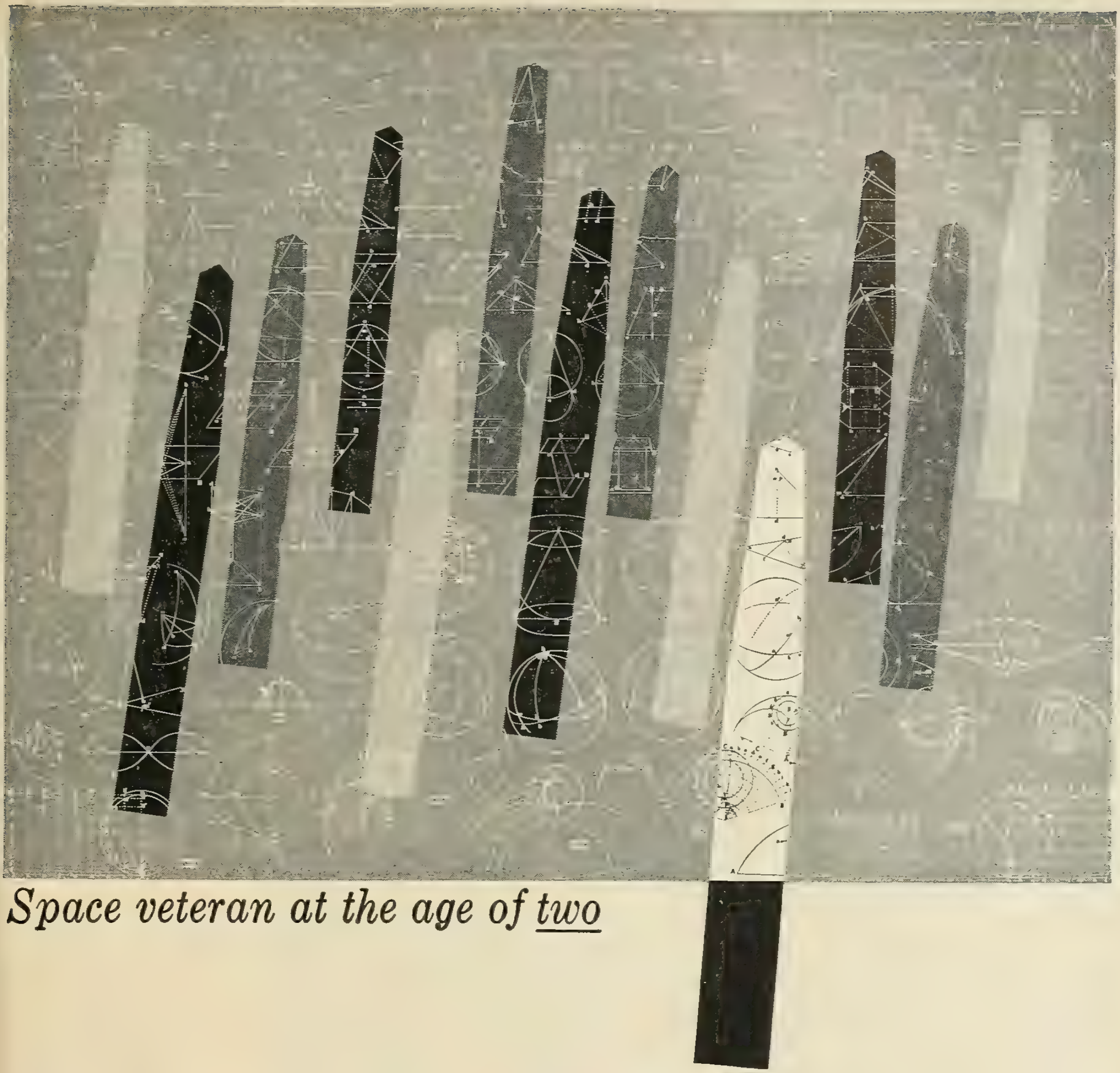
A recent Philco development is an all-electronic IR scanning system called "Filterscan." It uses a detector external to the scanner. The scanner, according to a company spokesman, contributes no measurable noise and is wavelength independent, thus noise limitations and spectral response of the system depend primarily on the detectors. Scan rate, using a fast-response detector, is comparable to standard TV.

The Air Arm Division of **Westinghouse Electric Corporation** for four years has been chiefly concerned with developmental work on IR systems for space and aircraft vehicles. Its areas of principal interest are reconnaissance, guidance, stabilization, and armament control.

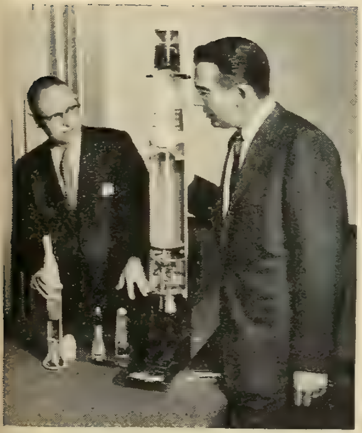
A number of complete IR search, tracking, warning and navigation systems have resulted from the efforts of the Santa Barbara Research Center, **Hughes Aircraft Co.** Out of this R&D work, design and production, a whole line of accessory devices and IR components have evolved: detectors, low-noise transistor preamps, and extensive photodetector test equipment.

In addition, SBRC has done extensive research into IR detector cooling, producing miniature cryostats, liquid transfer coolers, and miniature closed-loop coolers. It also has achieved significant results in increasing search and tracking range with shielding techniques (M/R Sept. 28).

The Research Center has nearly completed work on new far-infrared photo-detectors. It is believed that these will have greatly increased sensitivity and will employ improved coolers.



Space veteran at the age of two



The Air Force THOR, built by Douglas and three associate prime contractors, shows how well a down-to-earth approach to outer space can work. Since its first shoot early in 1957, it has had more than *forty* successful launchings...at a variety of jobs from re-entry vehicle testing at ICBM ranges to placing satellites in orbit. Initial planning for THOR included volume production tooling, ground handling equipment and operational systems. This typical Douglas approach made the giant IRBM available in quantity in record time, and THOR has performed with such reliability that it has truly become the workhorse of the space age. Douglas is now seeking qualified engineers and scientists for new projects with even more exciting prospects. Some immediate openings are described on the facing page.

Robert Johnson, Missile and Space Systems Chief Engineer, reviews results of a THOR-boosted 5000 mile flight with Donald W. Douglas, Jr., president of

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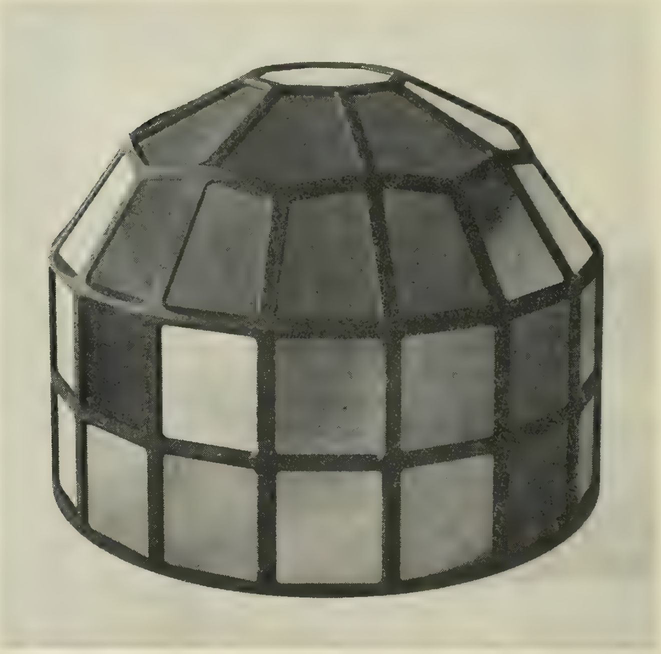
Some near-breakthroughs . . .

IN DEVELOPING associated IR devices for missiles, Eastman Kodak researchers use this insulated, 30-ft. diameter hemisphere to isolate infrared radiation sources and eliminate unwanted ones.



LARGE APERTURE, long-wavelength "irdome" developed by Ramo-Wooldridge for Sperry Gyroscope employs faceted configuration to simplify companion optical system design.

Another principal in the IR field is the Avion Division of **ACF Industries, Inc.** It is primarily interested in search and tracking systems, missile guidance and control, and passive IR velocity-over-height systems. Avion, earlier this year, achieved a great deal of success with its development of a commutating IR search system called CODES. Having very high sensitivity and relatively long range, it employs AC commutation with a multi-element system and a single amplifier (M/R, April 20).

Now under development in the company's research center are high-intensity pulsed-light communications and detection systems, mosaic tubes, IR thermal imaging vidicons and a star-occlusion system.

One of the country's largest IR systems groups is Crosley Division of **Avco Corporation.** The division is now working in the areas of reconnaissance and surveillance, ICBM detection, fire control, mapping, aircraft early warning, tracking, ranging, navigation, countermeasures and industrial applications. It is pressing for more developments in passive ranging devices.

HRB-Singer, Inc. has achieved success while confining its work to detection systems—all types. The company recently received a contract for 17 surveillance systems—cost, $2.3 million.

The Missile Systems Division of **Lockheed Aircraft Corporation** limits its efforts to research and development services. These include analysis of IR techniques for satellite and space applications; feasibility studies and preliminary design for detection, tracking and radiometric equipment; lab services for IR materials study.

Linde Company, a division of **Union Carbide Corporation,** is making significant advances in IR detector cell cooling. While they have produced a whole family of devices for cooling down to liquid nitrogen temperature (–320°F), preliminary designs have been completed for systems operating at liquid hydrogen (–423°F) and liquid helium (–452°F) temperatures. All are liquid refill systems.

Kearfoot Company, Inc., already producing a multitude of precision components and systems for missiles and aircraft, is now gaining a foothold in the IR field. Until recently, the company was primarily interested in detection systems in this field. But it has just been awarded an Air Force contract to develop a "solid-state multi-headed celestial comparater."

Specifically intended for space navigation, the device is to be completely solid state, with no moving parts.

A pioneer in the field of infrared photography, the **Eastman-Kodak Company** currently is working on the de-

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velopment of better physical and optical properties for IR filters, detectors and window materials in the 8-13 micron region. It recently introduced a new family of IR transmitting materials called IRTRAN Optics. The lenses, operating in the 1-to-8-micron region, retain high transmittance at 800°C and above. (Normally when subjected to this kind of heat, the lens itself would tend to emit IR radiation and thus "cloud" the target radiation.)

GB Electronics Corporation has achieved a near-breakthrough by combining microwave techniques with a semiconductor cell. The result is a "noiseless" amplification and improved sensitivity. Called an ultra-sensitive microwave IR detection system, USMID, it employs a parametric amplifier and harmonic generator. Because of its potentially small weight and size and low power requirements, applications for the device will be broad.

Another leading supplier of IR components and systems is the **Barnes Engineering Company.** A pioneer in the field, its activities are strong both in the military and industrial market. For missile and space applications, Barnes makes horizon sensors for space vehicle stabilization, radiometers, trackers, and surveillance systems. For industry it produces all types of IR monitoring, analysis and control devices.

Others important in the field are: **Baird Associates, Bausch and Lomb Optical Co., Minneapolis-Honeywell, General Electric, RCA, Perkin-Elmer, Servo-Corporation of America, Texas Instruments,** and **Ramo-Wooldridge.**

• **Future market**—A summary of problem areas in the IR field necessarily corresponds to those items currently under development. For one thing is certain, the future breadth of the IR market, as with many other young fields, is tied directly to its research breakthroughs.

It is significant that a great many of the companies surveyed indicated that this market, with just a few major developments, can and will increase by 3 or 4 orders of magnitude within the next five years.

Market estimates indicate that by FY 1965 total IR military expenditures may reach $240 million or more. Estimates for the combined defense-industrial market go as high as $1 billion. It is interesting to note the close relationship between individual company research efforts and market estimates. Those companies investing large amounts of time and money in the field are naturally extremely optimistic about the future.

It is believed that a marked increase in IR R&D money will occur within the next five years, but expansion will still be the spawn of research results.

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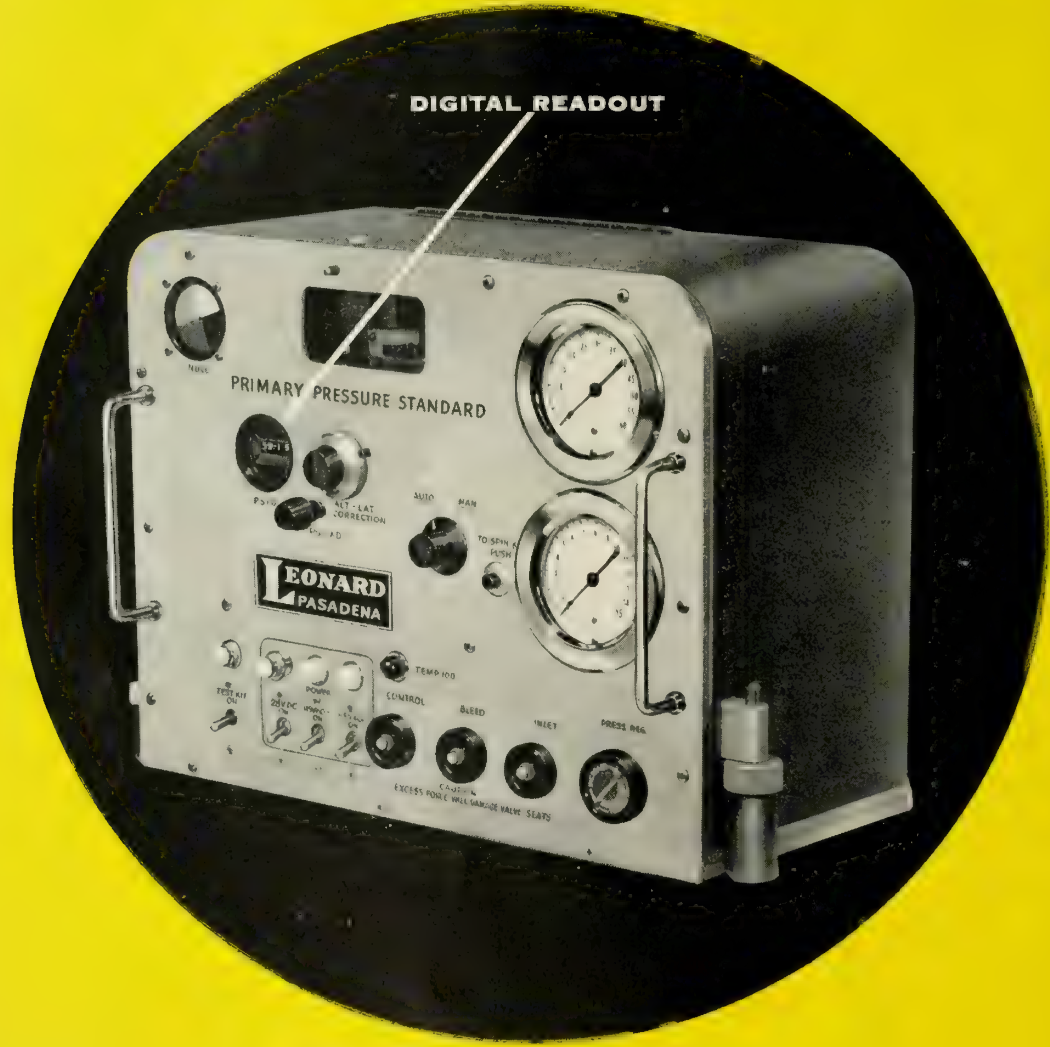

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Thus a corresponding increase is also foreseen in the use of IR devices and systems in the military.

- **Future developments**—Important developments now in progress are for the most part an indication of the problem areas in infrared technology. The problems are extensive but they fall in definite categories. For brevity, these are summarized items or techniques currently under development:
- Detectors—new cells and transducers having improved sensitivity and wider spectral response, (some using MASER techniques); better, uncooled cells and longer-wavelength detectors (8-13 microns); increased metallurgy research; improved characteristic reproducibility to provide cell uniformity and more stable sensitivity under adverse environments.
- Cooling—more efficient coolers; techniques or different gases to permit closer approach to absolute zero (to be practical, this must be achieved without excessive handling problems and high cost); better miniaturized cryostats.
- Optics—improved optical transmission materials with good physical strength; improved fabrication techniques.
- Circuitry—new electronic processing circuitry; better background discrimination techniques; low noise sampling devices; techniques for ranging and modulating the IR source.
- Design—improved reliability; miniaturized IR receivers (power supplies and electronics account for nearly 80% of total volume and weight of many systems); better scanning systems, filters, and image converters; coordination is needed between IR-system designers and detector manufacturers.
- Costs—more inexpensive materials in almost all areas are needed, but primarily for optics and detectors; cheaper cooling systems are needed.

Antenna Test Range Is Over Half-mile Long

SHERBURNE, N.Y.—A new antenna test range, over a half-mile in length, was opened here last week by **Technical Appliance Corp.** The facility will be used for development and checkout of antennas up to 60 feet in diameter. Pattern analysis as well as structural testing of towers and reflectors can be conducted at the site.

TACO produces a wide range of antennas, wave guides and feed systems for missile and aircraft telemetry, space tracking, and communications. It developed the complete DOPLOC system used in the Army "space fence" for satellite detection.

One of the 20th century's most significant events is the Cape Canaveral astronautical probe. Pan Am is proud that through our responsibilities to the Air Force in operation and maintenance of the Atlantic Missile Range, we have been active participants in the preparation and launching of every probe. We are pleased that members of our technical staff have had this opportunity to further their professional careers on projects of such significance.

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NEC Hears Reports on New *Explorers*

by an M/R Correspondent

CHICAGO—The 1959 National Electronics Conference held here at the Hotel Sherman was deemed a success both by those attending and by the exhibitors. Only the recruiting teams seemed disappointed—they vastly outnumbered applicants.

According to NEC officials, 188 companies were represented in 288 booths throughout the five exhibition areas. The total of 8700 engineers, scientists, educators, military representatives, and student guests attending the three-day meeting fell somewhat below pre-conference estimates. But it appeared to most observers that the various technical sessions and panels drew bigger-than-usual audiences.

Exhibitors also indicated that the average registrant investigating booths was in a position within his own organization to decide whether to purchase and use the items shown. They, together with the large number of educators from nearby universities, set the tone of the conference.

- **Principal speakers**—Dr. John C. Green, director of the Office of Technical Services-Commerce Department, discussed the universal problems of digesting and effectively disseminating technical information. He revealed the importance with which the problem is viewed by the Russians and how they are striving to reduce to 3 months their present 7-month time for processing abstracts of world information.

He suggested that "information scientists or researchers" be utilized having a salary and corporate level equal to that of technical scientists and researchers. With the full backing of the government and industry, he said, we too could learn to pool, use, and keep pace with technical findings effectively.

On succeeding days, other principal speakers were J. Lewis Powell, and Dr. F. A. Kraemer, both of the Department of Defense. Powell discussed the transition of "Cave Men-Space Men." Kraemer reviewed "U.S. Capabilities in the Battle for Men's Minds."

- ***Explorer VI* results**—Of particular interest was a presentation revealing many of the important results obtained from *Explorer VI.* A full-size model of the "paddlewheel" satellite was shown by the three **Space Technology Laboratories'** men responsible for its sophisticated instrumentation, Drs. Bagely, Booton, and Chalmers.

One important finding, said Dr. Booton, was the isolation of the most hazardous region in the Van Allen belts. This, he said, is a belt 5 kilometers in depth at an altitude of approximately 2000 km, having an unusually high proton concentration.

Besides the vast amount of data being received, the satellite has provided other significant returns, said Dr. Bagely: it demonstrates the worth of the highly sophisticated power system utilizing vast banks of solar cells, and it also shows our ability to interrogate and command the satellite via radio, plus the ability to change information rates.

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Also discussed was the capability of the telemetering transmitter employed. The current device has a 5-7 million-mile range. But, said the STL experts, with the addition of a small 150-watt transmitter unit and using the Jodrell Bank paraboloidal-reflector antenna, range could be extended beyond 50 million miles for space communication.

- *Explorer VII* **details**—A paper of high current interest was presented by Prof. R. Parent and Drs. W. B. Swift and Verner Suomi, University of Wisconsin, describing the instrumentation for the heat-balance measurement program for *Explorer VII*. This low-cost (roughly $150,000) effort could well have far-reaching results for future weather control.

Through a better knowledge of the total heat input from the sun, reflected energy, and earth heat radiation, the authors hope to achieve a fundamental meteorological understanding. To control weather, two facts must be clearly understood, said Dr. Swift: atmospheric motion or circulation and the reasons for rapid large-scale weather changes.

- **Abstracts**—Many significant papers covering subjects associated with the missile and space field were presented. A bound volume of the *Proceeding of the NEC*, Volume 15, will be published early in 1960. Copies may be obtained at a cost of $10 by writing the National Electronics Conference, 228 North LaSalle, Chicago 1, Ill.

Missile Support Test Chamber Being Built

TORRANCE, CALIF.—A new environmental testing chamber for wheeled missile support equipment is being constructed by **Horkey-Moore Associates.**

The unit will be programmed and data will be recorded automatically on tape. The operating temperatures range from −100°F to 200°F and the humidity conditions can be varied from 40% to 100% over a temperature range of 40°F to 200°F.

Talos missile, prime armament of the missile-age cruisers, blasts off from the U.S.S. Galveston.

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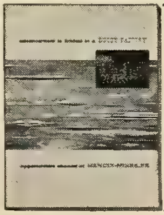

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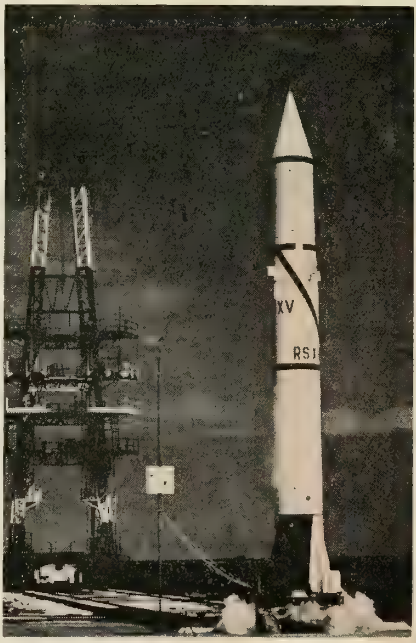
Ducts, pods, heat-shields, electronic components and other high-temperature parts for missiles or aircraft can be fabricated easily of lightweight silicone laminates. These laminates have good strength, good heat resistance, and are unaffected by moisture, weathering, ozone and corrosion, thermal shock or fungus attack. Dow Corning silicone resins, coupled with glass cloth or other inorganic fillers, give better strength-to-weight ratios "at temperature" than many light metals. And they're simple to form.

In the North American Aviation Super Sabre F-100, for example, designers needed a rigid material for the drag-chute case. As this chute case fits right up against the engine at the rudder base, the rigid outer wall of it must: 1) reflect heat away from the chute: 2) resist jet engine ambients: 3) retain structural strength without necessity of replacement.

Development engineers tried numerous "high-temperature" plastics without success. Too much heat. Then they hit on silicone-glass laminate, gold-metallized for heat reflectance. Not only did this prove entirely suitable, it also turned out to be more easily formed. The finished part can endure continuous service at 750 F and intermittent exposure to 1200 F. Vibration resistance is excellent.

Silicones for the Army Redstone

In the Redstone, Chrysler Missile Division engineers employ silicone laminates several ways. As in the case of the F-100, large heat shields behind the Redstone's engine compartment are fabricated of the laminates because of their light weight, heat resistance, thermal impedance. Also, due to excellent electric strength and creep resistance, silicone laminates are utilized for terminal boards in black boxes within the missile and in Ground Support Equipment control boxes.



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missile business . . .

By WILLIAM E. HOWARD

The U.S. Labor Department has surveyed the dimensions of U.S. "missile activity" and come up with these vital statistics: As of October, 1958, there were 319,300 persons producing missiles and their components. This was a 38% increase from the previous 12 months. By last April, the department estimates, total employment had jumped to 350,000.

Biggest Number of missile workers—125,600 . . .

were in aircraft plants. The remaining 61% were distributed over 14 major industry groups. Ordnance claimed 21% and the communications field 18% as of a year ago.

The proportion of aircraft employees working on missiles rose from 8% in 1957 to 17% last year. Comments the department: "It is evident that this activity has been extremely important in keeping the decline in aircraft employment within moderate proportions."

Distribution by states showed California leading . . .

with about 127,000 missile personnel, 40% of the national total. New York was second in the 1958 survey with 24,000 and Massachusetts third with 16,600. Other states: Washington—13,600; North Carolina—13,500; New Jersey—12,200; Maryland—11,900; Michigan—11,800; Pennsylvania—10,900; Minnesota—10,000; Alabama—9,300; Florida—8,800; Arizona—6,900; Missouri—6,900; Colorado—6,600 and Texas—5,800. The remaining states combined had 23,500.

It should be noted that the Labor Department survey was confined to "missile activity." The Department defines this as including "research, development or production of complete missiles (including rockets), launching devices, ground control and testing units, propulsion units, war heads, fuel, electronic components, and other parts designed for inclusion in the missile or in ground support equipment."

Surprisingly enough, only 433 private . . .

and government establishments were covered in the survey. Missile plants were identified through DOD lists of contractors and subcontractors. "Although it is presumed that the coverage represents the greater proportion of all establishments engaged in missile work," says the department "complete information as to the actual total number of firms engaged in missiles work was not available."

This admission on the part of the Labor Department may come as something of a minor shock to the Small Business Administration and perhaps cast some suspicion on the reliability of the survey. SBA issued more than a year ago a "Missile Sub-Contracting" book containing names, addresses and type of components manufactured by more than 2000 small firms. The SBA also lists more than 1000 R&D concerns—about 300 of them in missiles—in another directory which also was available to its fellow Federal agency.

M/R recently has published several surveys which indicate a substantially higher degree of activity than found by the Labor Department.

People hard at work in the $7 billion missile field . . .

may also be interested to know that the Labor Department does not recognize their scope of endeavor as an "industry." Here's the official finding from the survey: Since there are only a relatively small number of establishments in which the principal activity is the production or assembly of *complete* missiles, this does not constitute a sufficiently large body of economic activity . . . for designation as a separate industry."

May we point out: only a relatively small number of companies assemble *complete* autos in the automotive industry.

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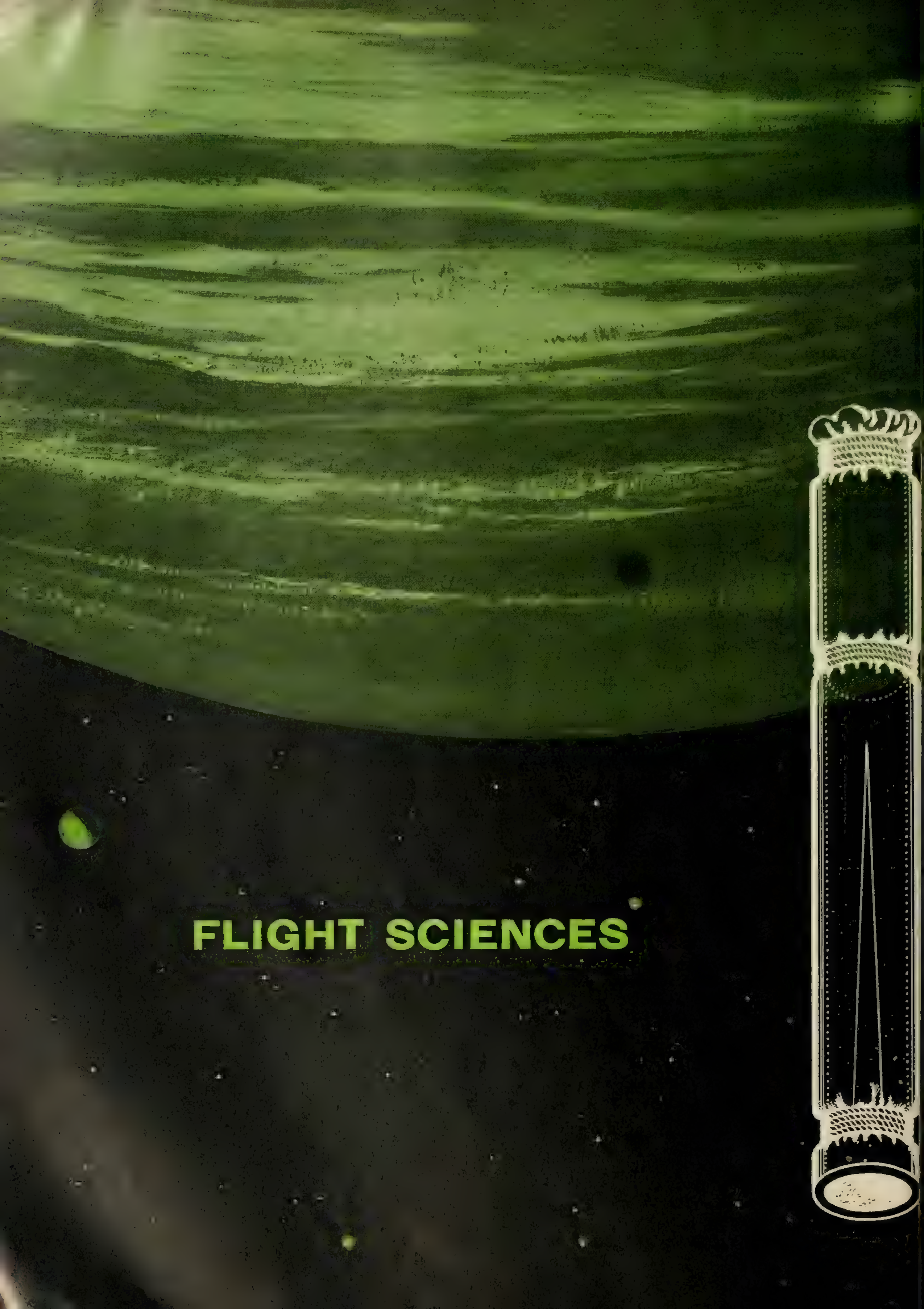
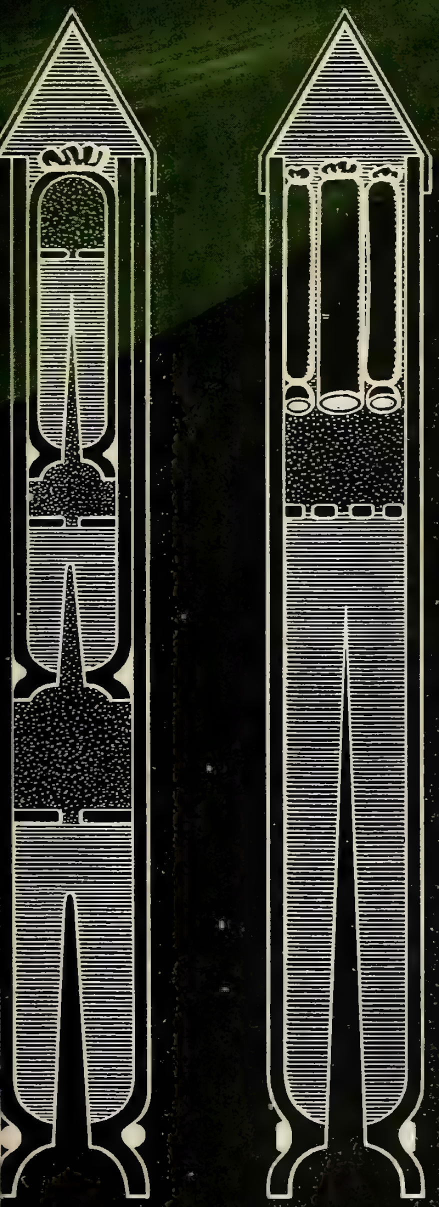


FLIGHT SCIENCES



FLIGHT SCIENCES: Principle of the step or multi-stage rocket, considered fundamental to the art of modern missiles and space flight, was set forth as long ago as 1650 by Kazimierz Siemienowicz, lieutenant-general of ordnance to the king of Poland. His design featured a 3-stage rocket with each step having its own gunpowder fuel, fuse, and nozzle.

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Finn Finds Feasible Method of Welding Molybdenum for Structures

by **John F. Judge**

WASHINGTON—The production of molybdenum welds with the strength and room-temperature ductility required for structural applications is now possible through the efforts of the **Finn Aeronautical Division,** Hawthorne, N.J.

The successful spot and fusion welding techniques are the result of several years' research, during which the company also delved into another major molybdenum problem—oxidation at high temperatures. After a thorough investigation of all coatings now available, various coatings have been found which will prevent oxidation of structural members at temperatures above 2000°F.

Finn cannot now reveal the actual method by which it produces satisfactory molybdenum welds, but Vice President Charles W. Brunstetter describes the process this way:

"It might best be considered as a development of new procedures and processes of welding, rather than a new welding method. It can be performed by ordinary welding equipment, and with only the ordinary precautions taken with any high-temperature metal."

The hundreds of weldments already made on an experimental basis have been proved again and again, Brunstetter says, and while further work remains to be done, they have certainly created a wave of interest and subdued excitement throughout the industry.

• **Flattening & recurving**—Among the most impressive of these sample weldments are curved sandwich structures, which are ductile enough at room temperature to be repeatedly flattened out and returned to their curved position.

Such ductility was so unheard of in molybdenum welds that when a U.S. government expert saw it being done during a West Coast exhibit he refused to believe at first that it actually was a molybdenum sandwich . . . and then had to be convinced that a low melting point braze had not been used. Such reactions are typical among the molybdenum experts throughout the country, Dr. J. Z. Briggs of **Climax**

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Molybdenum Company said.

"At the very least, it shows that molybdenum welding is possible—that welds with the needed structural strength can be made."

• **Government cautious**—Government molybdenum experts, as might be expected, are somewhat cautious in their appraisal of the Finn results, pending the actual production and use of molybdenum welds in structural applications.

But even so, there is no lack of enthusiasm for the possibilities revealed by the process.

E. W. Matthauser of the Structures Research Division, National Aeronautics and Space Administration, points out one such aspect.

"The ability to use molybdenum structures," he said, "would raise the maximum operating temperatures from the present 1800-2000°F level to the 2500-3000°F level. Such an increase should improve vehicle performance and would permit a wider selection of trajectories for re-entry vehicles."

• **Large pieces**—N. E. Promisel, Chief Materials Scientist of the Navy's Bureau of Aeronautics, said that his organization was keeping a close and interested watch on this new method though he has not had an opportunity to evaluate them in the laboratory, the welded sandwiches he has seen appear very impressive.

"If it can be done on a reproducible basis, with ductility and uniformity in large pieces," he said, "it would indeed be a very important development, in view of the real need for a practical, reliable method of welding molybdenum and its alloys in a variety of gages and large sizes."

This matter of production, of course, is of direct concern to the prime contractors on missile programs. Like the government research men, they are vitally interested in any feasible method of producing welded molybdenum structures.

• **Uniform quality**—In the Finn organization itself, officials are fully aware that more development work remains to be done before large molybdenum welded structures become commonplace, and much of this work is now in progress.

But even now, they feel, the welds already made, and the test results on them, prove that they have found the key to producing perfectly satisfactory weldments for structural uses. The rest is a matter of expanding and perfecting the work already done.

Also of significance, is the interrelationship between welding molybdenum and the other two great molybdenum problems—oxidation at high temperatures and the difficulty of producing sheet after sheet of molybdenum with the same quality in each sheet, or even of maintaining the same quality in all portions of the same sheet.

The ability to successfully weld molybdenum lessens in some respects the importance of both these other problems. For instance, there are some applications where oxidation is not a problem, or at least one of secondary importance. In cases like this it would now be possible to use a welded structure, even if the oxidation problem were never solved.

Successful welding can go a long way toward overcoming the problem of uniform sheet quality, as it is much easier to maintain such uniformity in small sheets than it is in large ones. Since the uniform small sheets can be welded into large ones, it is not difficult to see how satisfactory welding can contribute to uniform sheet quality.

Also, there is a general feeling among industry metallurgists that work such as Finn has done on molybdenum will be a significant help in learning how to work with the other refractory metals, since in many areas the same types of problems exist.

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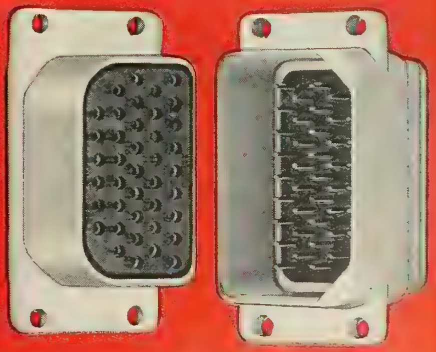

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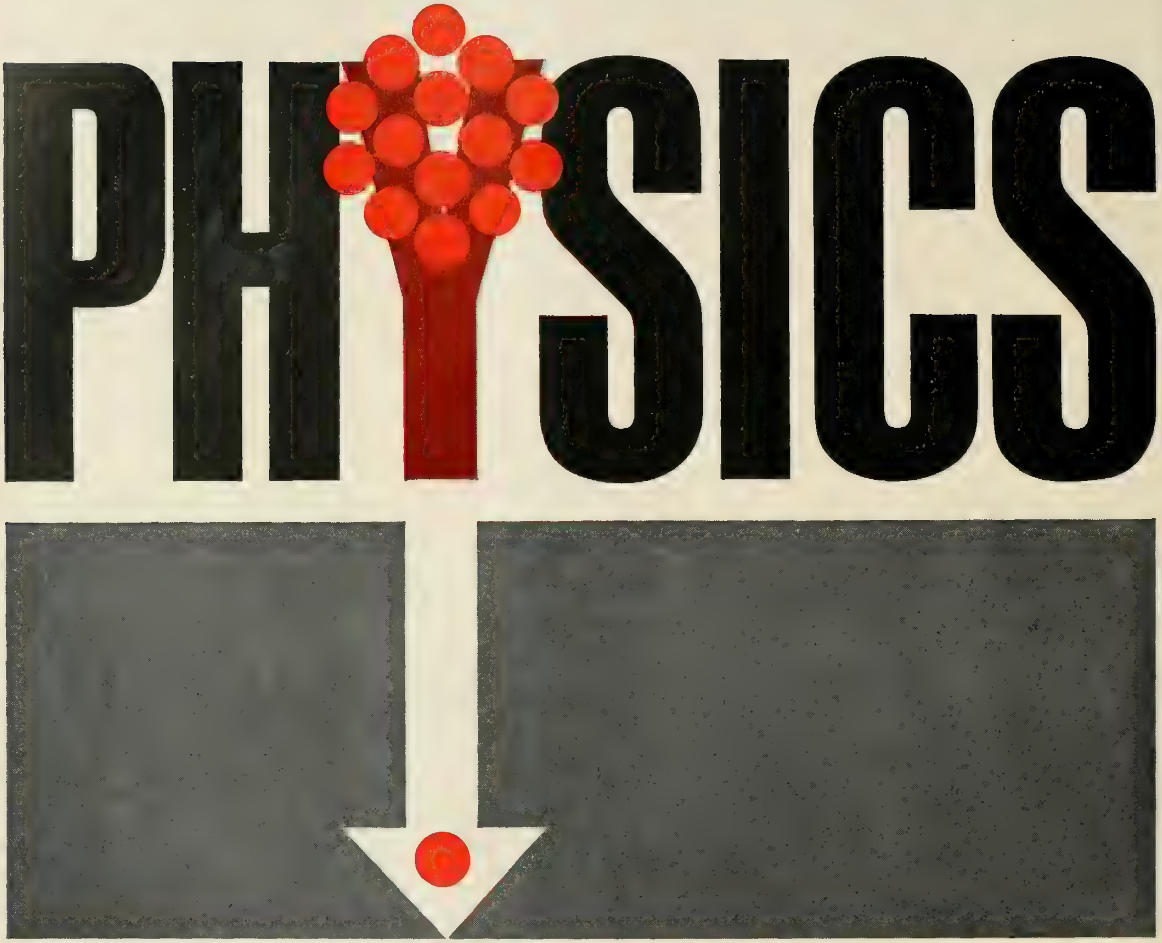

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A compact microwave filter which passes only specific frequencies above the pass band is announced by **Airton, Inc.,** a division of **Litton Industries.**

Initial designs constructed are for C-Band operation, but reports say they can be developed for any waveguide size or frequency range from 3000 to 36,000 MVPS and for larger or smaller pass and stop bands. The unit consists of a straight section of waveguide with four E-plane cutoff stub arms located along one broad wall of the waveguide. Higher rejection in the stop band is obtained by using more stub sections.

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propulsion engineering...

BY JAY HOLMES

A new approach to solid propellants...

is suggested by Dr. Milton Farber of **Rocket Power Inc.** Instead of using the fuel as a binder—that is, to provide the strength and elasticity needed in the grain—Farber proposes using the oxidizer as a binder. In a paper at the recent **Avco**-Air Force symposium on advanced propulsion concepts, he suggested that fluorine-containing polymers can serve as excellent oxidizer-binders.

Many high-energy fuels...

ruled out because they lack binder properties, could be used if an oxidizer could do this job. An important advance might result if the necessary physical properties could be provided by the oxidizer, which already accounts for 70 to 80% of the weight of a composite solid-propellant grain. The advance conceivably might provide the 10-to-20 seconds of additional specific impulse wanted by the Advanced Research Projects Agency of the Defense Department.

Very low molecular-weight product gases...

are another approach to this continuing problem. Specific impulse varies inversely as the square root of the mean molecular weight of the product gases. That is, the impulse increases as we reduce the average weight of the molecules of product gases.

This is the reason...

underlying the popularity of hydrogen, the lightest element, in both solid and liquid propellant systems. When hydrogen burns in oxygen, the resultant H_2O has a molecular weight of 18. The only practical way to lower the average is not to burn all of the hydrogen. This is done in liquid-fuel systems using liquid hydrogen.

Flame temperature need not be high...

if product gases have low enough molecular weight, G. F. Huff of **Callery Chemical Co.** told the symposium. He suggested also that propellant systems need not be considered merely as combinations of oxidizer and fuel. He proposed considering the systems as suppliers of certain amounts of energy and specified combustion products.

This is the approach that solved...

the aluminum puzzle several years ago. It was believed on the basis of thermodynamic calculations that adding aluminum powder to a solid propellant grain ought to improve the impulse considerably. Aluminum is a high reactive metal.

There was only one trouble...

It didn't work in practice. Adding 9 or 10% aluminum, as called for by the calculations, didn't help at all. No appreciable rise in impulse was noted. Keith Rumbel of **Atlantic Research** re-examined the problem on the basis of combustion products. Obviously, there could be no error of such magnitude in the amount of energy assumed to be in the system. This provided the key. The products had been assumed to be aluminum oxide, carbon dioxide and water vapor.

The actual combustion products...

are carbon monoxide, hydrogen and aluminum oxide. The heat added by using 9 or 10% aluminum is used up in dissociating CO_2 and H_2O. When he made his thermodynamic calculation on the basis of these products, Rumbel came up with a requirement for about 20% aluminum by weight. When he tried adding that much aluminum, he obtained the predicted improvement.

The moral of the story...

is one that applies in research as well as in ordinary life: Don't take anything for granted.

—more about the missile week

- **Washington**—The White House was expected to make a "political" appointment in selecting a successor to Defense Department Controller Wilfred J. MacNeil, who is resigning to become president of Grace Lines.

- **Dallas**—There is speculation **Chance Vought's** *Regulus,* dropped by the Navy earlier this year, may be used as an interim target missile for *Nike-Zeus* in tests at Kwajalein. The air-breathing *Regulus* can carry about 1000 pounds of electronic gear as a target and possibly may be modified to radar-simulate various types of re-entry bodies.

- **Washington**—Congress was urged to straighten out a conflict between U.S. Patent laws and "second source" procurement requirements of the Defense Department. George J. Pandapas, president of **Electro Tec Corp.,** Hackensack, N.J., said patented inventions with a "legal . . . protected monopoly" frequently are "shunned" by DOD agencies which insist upon at least two sources of supply.

- **Tyndall AFB, Fla.**—Gen. Benjamin W. Chidlaw (USAF Ret.), vice president of **Thompson Ramo Wooldridge, Inc.,** predicted that within 10 years it will be possible to watch through TV on earth the action of space ships and "our personnel operating a defense program for outer space."

- **Cambridge, Mass.**—Fred L. Whipple, Director of the Smithsonian Astro-physical Observatory, said that "telepuppets"—remote-controlled robots with TV eyes—probably will build the first space platforms for launching moon and interplanetary expeditions. In a report to the Office of Naval Research, he said he doubts that it would be safe or efficient to have the work done by human beings wearing space suits.

- **Los Angeles**—A miniature carbon dioxide sensing device to check the air supply for the first Project *Mercury* pilot will be developed by **Beckman Instruments, Inc.** The company will build 13 of the sensors under a $48,000 order from **McDonnell Aircraft Corp.,** makers of the *Mercury* capsule.

- **Washington**—The Navy is pushing an equatorial launching of space vehicles from ships, rather than a costly Pacific island site. Several major contractors are teaming up with A&E outfits to submit proposals. NASA is due to issue a report shortly on the feasibility of an equatorial land site.

- **Washington**—Negotiations to establish IBRM bases in Greece have come to a standstill and are not expected to be resumed. However, an agreement to place a single IRBM squadron in Turkey was due for announcement soon, government officials said.

- **Fort Belvoir, Va.**—An Army Nuclear Weapon Coordination Group has been set up here to monitor the Army weapons program from design stages through operational capability. The group also will work in the field of nuclear weapon ssafety.

Advances Reported in Working 'Exotic' Metals

Exotic metals for spacecraft took several strides forward last week.

Standard Pressed Steel Co. opened a $100,000 pilot plant operation for fabricating bolts and other threaded parts of beryllium. Standard is using bar stock of 125,000 psi tensile strength, equal to 500,000 psi steel on a strength-to-weight basis.

The **Bendix Aviation Co.** obtained a patents license covering alloys of zirconium, the rare earths, thorium and magnesium from **Magnesium Elektron Ltd.** of Manchester, England. The Bendix Foundries at Teterboro, N.J., will make use of the Elektron casting process.

Stauffer-Temescal Co., an affiliate of **Stauffer Chemical Co.,** announced development of a series of tantalum-tungsten alloys with melting points ranging from 5430 to 6150°F, which retain tensile strength of about 15,000 psi at 4500°F. Stauffer and **Aerojet-General** jointly worked on their application to critical components of solid-fueled rockets. The alloys are produced by Stauffer's electron-beam melting techniques.

Westinghouse reported perfection of a process that makes it possible to construct large objects of tungsten, molybdenum and other strong high-temperature metals. The process compresses metal powders into bars, after which they are baked in an oven.

The **Pyromet Co.** of South San Francisco, Calif., said it has developed a high-vacuum furnace for brazing and heat-treating titanium, beryllium, zirconium, molybdenum, tungsten, tantalum and niobium. The furnace can hold a 10^{-5} mm vacuum at room temperature and 10^{-4} mm in the 1800-2000°F range.

Mergers & Expansions

Federal Manufacturing and Engineering Corp., Garden City, N.Y., moved into missile tracking and photographic instrumentation with the acquisition of **Cameraflex Corp.** and **Television Specialty Co. Inc.** . . . **Consolidated Electronics Industries Corp.** took over **Philips Industries Inc.** and **Central Public Utility Corp.** to form a new electrical, electronics, pharmaceutical, chemical and utility concern at Wilmington, Del. The merged firm declared an immediate 25-cent dividend. . . . **Documentation Inc.** of Washington, D.C., was merged into the **Benson-Lehner Corp.** of Santa Monica, Calif. Benson-Lehner said Documentation's data-retrieval techniques will prove valuable. . . . **Chance Vought Aircraft** made a similar move with the acquisition of **National Data Processing Corp.,** also of Dallas. . . . To obtain major metal fabrication facilities so it can bid on "many important projects," **Telecomputing Corp.** of Los Angeles bought **Monrovia Aviation Corp.** which had been a subsidiary of **Carrier Corp.**

. . .

To be closer to missile-makers, **Johnston & Funk Metallurgical Corp.** moved its headquarters and plant from Wooster, Ohio, to Huntsville, Ala. . . . **Electronautics Corp.,** a new enterprise, was formed in Maynard, Mass., to manufacture reinforced plastics for the electronic and astronautic industries.

ABMA Switch Leaves Space Plans Uncertain

By William E. Howard

WASHINGTON—The future of the nation's space program remained in doubt last week following transfer of the Army Ballistic Missile Agency to NASA and with it responsibility for large space booster development.

In ordering the switch to civilian control, President Eisenhower left open these questions:

- Whether there will be an increase in funding for NASA and, if so, how much.
- Whether the 1.5 million-pound-thrust *Saturn* vehicle being developed by ABMA would be dropped in favor of some other large engine—possibly the 400,000-pound **Rocketdyne** E-1—or continued.
- Whether the move will signal the start of a "crash" program to try and overtake Russia in the conquest of space.

There was also some speculation immediately after announcement of the shift last Wednesday whether Dr. Wernher von Braun, civilian chief at ABMA, would stay with his team. Von Braun said earlier in the week that should ABMA be denied a "challenging" job under civilian control, he would resign.

Transfer of ABMA takes the Army completely out of the space field. All military space projects were placed under the jurisdiction of the Air Force last month. DOD has said it has no immediate requirement for a booster as big as *Saturn*. Presumably, if such a requirement does come up in the future, the booster will have to be procured through NASA.

The President said the shift to NASA was intended to "strengthen the national space effort and provide for America's changing requirements in this field."

Von Braun's Development Operations Division, which includes 4300 persons at Huntsville, will be integrated into NASA immediately—although under the Space Act Congress has the right to object anytime within the first 60 days of the session starting in Jan.

- **Reservations**—Several high NASA officials are known to be lukewarm both about having the ABMA group handed them, because of the lack of funds, and about *Saturn*, which is considered by many to be much too costly for its space needs. Consideration reportedly is being given by DOD to clustering a pair of E-1 engines into an 800,000-pound-thrust booster. This approach is said to be cheaper than the *Saturn* cluster for which $100 million already has been programmed and which is expected ultimately to cost $300 million or more.

- **Thrust years away**—NASA already is developing the 1.5-million-pound-thrust Rocketdyne F-1 (formerly known as *Nova*). About $20 million is being spent in FY 1960 on the F-1, and it is expected to take about six years to perfect the single-chamber booster. Later, it is planned to cluster four or Six F-1's into one booster of upwards of 6 million pounds thrust. However, this will take an additional two or three years.

Until these multi-meg boosters are ready, the U.S. will be competing against Russia with boosters only as big as the 360,000-pound *Atlas*, and be prevented from attempting any manned exploration of space outside of the *Mercury* orbital capsule. Many space experts have been urging a speedup in big booster development to compete with the 800,000-pound-thrust Russian rockets.

The decision to transfer ABMA came after a 70-minute White House conference of the President and his top military and space officials—and including acting Budget Director Elmer Staats. Army Secretary Brucker did not attend. But sitting in were Defense Secretary McElroy; Gen. Nathan M. Twining, chairman of the Joint Chiefs of Staff; NASA Chief Dr. T. Keith Glennan and his deputy, Hugh Dryden; Deputy Defense Secretary Thomas S. Gates; Dr. Herbert York, DOD's director of research and engineering; and Mr. Eisenhower's science adviser, Dr. George Kistiakowsky.

Bringing the issue to a sudden boil was Maj. Gen. John B. Medaris' decision to quit as chief of the Army Ordnance Missile Command. Medaris made the announcement Monday night. The next morning, at a breakfast meeting in Washington, Von Braun lashed out at the leisurely and indecisive pace of the entire space program. He implied that this was the reason Medaris was resigning. Medaris later denied his resignation was an act of protest. He said he was "tired" and had actually handed in the letter 60 days previously, long before the Air Force was given the dominant role in military space activities.

Von Braun declared that the nation was "wasting time and energy in ponderous reappraisals and re-examinations" of space programs. A big booster program must be pursued boldly, he said, "if we don't mean to abandon the heavens to the Reds."

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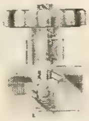

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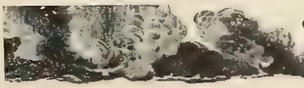

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MISCELLANEOUS

Robertshaw-Fulton Controls Co., Aeronautical & Instrument Division, Richmond, Va., has received two contracts for special change-of-state components ovens for use in a missile tracking system being designed by **Space Technology Laboratories, Inc.** Amounts not disclosed.

$838,163—**The Martin Co., Nuclear Div.**, for development of a simplified and highly advanced nuclear reactor system.

$400,000—**Radiation, Inc.**, for a highly advanced PCM flight test data acquisition and data processing system. (Subcontract from **Norair Division, Northrop Corp.**).

$200,000—**Hallamore Electronics Div., The Siegler Corp.**, for (1) design and manufacture of special checkout equipment for LMSD space vehicles, (2) design fabrication and installation of modifications to a tracking antenna in Hawaii; (3) for special shipboard power supplies for atomic submarines. Three contracts.

NAVY

Tasker Instruments Corp., Los Angeles, for development and production of special launcher test sets for the *Sidewinder* missile. Amount not disclosed.

ARMY

$7,300,000—**Hughes Aircraft Co.**, Culver City, Calif., for increasing the capabilities of the company's missile monitor system used in connection with the *Nike* and *Hawk* missile batteries.

$1,608,000—**Telecomputing Corp.**, Los Angeles, for production of gyro systems for the *Nike-Hercules* ground-to-air missile. (Subcontract from **Western Electric Co.**)

$1,000,000—**Summers Gyroscope Co.**, Santa Monica, Calif., for a quantity of "free" gyros destined for use in the *Lacrosse* missile. (Subcontract from **The Martin Co.-Orlando.**)

$500,000—**Temco Aircraft**, Dallas, Tex., for building aluminum shipping and storage containers for *Sergeant* missiles.

$200,000—**Dunn Engineering Associates, Inc.**, Cambridge, Mass., for design and construction of specialized electronic test equipment for production testing of radome and radar antenna components of the *Hawk* missile. (Subcontract from **Raytheon Co., Missile Systems Division.**) Two contracts.

$199,779—**J. R. Cantrall Corp.**, El Monte, Calif., for radar tower at Norad Control Center.

$22,956—**Potter Instrument Co.**, Plainview, N.Y., for digital magnetic tape recorder reproducer.

AIR FORCE

Food Machinery and Chemical Corp., San Jose, Calif., for building support equipment for *Bomarc*. (Subcontract from **Boeing Airplane Co.**) Amount not disclosed.

$30,271,000—**Boeing Airplane Co.**, Seattle, for spare parts and support equipment.

$7,776,637—**Hughes Aircraft Co.**, Culver City, Calif., for repairs and modification of fire control and weapons control systems components.

$505,000—**Varian Associates**, Palo Alto, Calif., for electron tubes.

$432,186—**Prodelin, Inc.**, Kearny, N.J., for radio frequency transmission line acceptable fittings and hardware, pressurizing system for use with *Bomarc* GATR sites.

$400,000—**Consolidated Avionics Corp.**, Westbury, N.Y., for a large scale data processing system involving advanced computer techniques. Classified contract.

$200,000—**System Development Corp.**, Santa Monica, Calif., for additional facilities for the SAGE programming and training program.

$200,000—**Stellardyne Laboratories, Inc.**, El Cajon, Calif., for extensive testing and evaluation work on missile components.

$100,000—**Jonathan Manufacturing Co.**, Fullerton, Calif., for delivery of an undisclosed quantity of ultra-thin ball-bearing slide mechanisms for *Bomarc B* ground installations. (Subcontract from **Aero-Space Div., Boeing Airplane Co.**)

$81,924—**James Pastoriza Associates**, Boston, for development and construction of a satellite orbit simulator and display prototype.

$70,000—**The Perkin-Elmer Corp.**, Norwalk, Conn., for optical systems to be incorporated into satellite tracking cameras.

SS 10

SS 11

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people

ZAMBROW

Dr. John L. Zambrow has been appointed director of engineering for Sylvania-Corning Nuclear Corp. He has been with Sylcor for the past ten years, most recently as manager of the Metallurgy Dept., and was previously associated with Culter-Hammer Manufacturing Co., Battelle Memorial Institute and Ohio State University Research Foundation.

Aikman Armstrong has been appointed chief application engineer for nuclear products, marketing division of The Marquardt Corp.'s Power Systems Group.

With 25 years in the field of engineering, business administration and law, Armstrong formerly served as executive assistant in contracts and proposals at North American Aviation, and as assistant general manager of Turbocraft Co. He also was chief staff and administrative engineer in the nuclear projects department at Aerojet and was associated with the Atomic Energy Commission as chief of the process engineering section.

JATRAS

Stephen J. Jatras has been named director of engineering for Lockheed's Electronics and Avionics Division.

Jatras joined the the company in 1956 as a staff scientist in the Missiles and Space Division, serving as business administrator for the research branch and manager of the flight controls and guidance division before becoming assistant to the director of research.

Prior to joining Lockheed, he was vice president and chief engineer of Midwestern Instruments, Inc.

Consolidated Electrodynamics Corp. has named **Herbert I. Chambers** as associate director of the DataTape division. He will direct the activities of the Engineering Dept., Special Projects Dept., and Magnetic Head Section. **Fred F. Grant,** formerly a senior supervisory engineer, was named manager of the Engineering Dept., and **Edgar E. Hotchkin,** a senior development engineer, named manager of the Magnetic Head Section.

Dr. John J. Myers has joined the research staff of Hoffman Electronics Corp.'s Science Center as a senior scientist.

Dr. Myers, former research assistant

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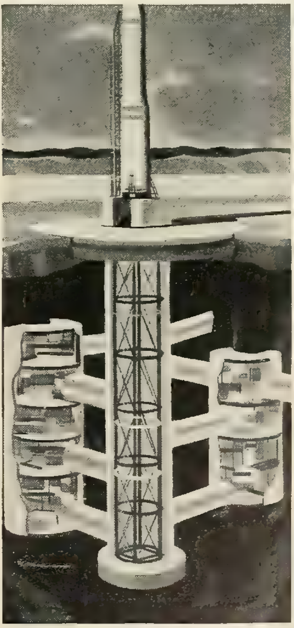

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professor at the coordinated Science Laboratory of the University of Illinois, will be responsible for studies in industrial electronics, including data processing.

SATYENDRA

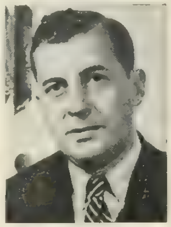
Dr. K. N. Satyendra has been elected director of research, Electronic Systems and Equipment Dept., at Nortronics division of Northrop Corp. He will direct studies and research in applied sciences and technologies directly relating to space electronics.

Dr. Satyendra formerly associated with the Advanced Systems Planning Group of Westinghouse Defense Products, directing long-range research and development programs in space technology. He joined Westinghouse in 1954 as a member of the Air Arm division and was principal investigator in many weapon system studies.

General Electric's Rocket Engine Section has announced establishment of a new organization responsible for the manufacture of solid rocket cases, naming **R. H. Wettach,** manager.

Wettach joined GE in 1950 as a test engineer and subsequently held assignments in the assembly and manufacturing operations of the company's Production Engine Dept.

Bernard M. Goldsmith has been appointed president of Nytronics Inc. He was formerly president of Essex Electronics. Nytronics Inc. is a recent consolidation of three companies now operating as divisions of the parent company—Essex Electronics, Essex Electronics of Canada and Sutton Electronics.



BERGEN

William B. Bergen, president of The Martin Co., has been named a director of The Black & Decker Manufacturing Co., replacing the late **Stanley B. Trott.** Bergen, who began his career at Martin in 1937 as vibrations engineer, has been president of that firm since last April and was responsible for initiating development of the Air Force TM-61 *Matador* missile and the Navy's *Viking* research rocket.

G. W. McGinley has been named sales manager of Stromberg-Carlson division of General Dynamics Corp., responsible for all sales activities for the firm's line of high-speed electronic printers, data display and recording devices, charactron-shaped beam tubes and other electronic equipment.

Prior to joining the company, McGinley was supervisor of system sales for Union Switch and Signal division of Westinghouse Airbrake Co.

The following appointments have also been announced:

Cooper Alloy Corp. has made two changes within its marketing division: **Stuart F. Cooper** from sales manager, Foundry Products Division to sales manager, Vantom Pump and Equipment Corp. division; **Harold W. Rimalover** from sales engineer to sales manager, Foundry Products division.

Maj. Gen. Donald N. Yates has been designated DOD representative for Project *Mercury* support operations. **Capt. James G. Franklin,** Navy, will assist Gen. Yates in the recovery operation.

The Range Systems division of Chance Vought has announced the following appointments: **S. O. Perry,** division manager; **C. H. Coleman,** manager of engineering branch; **J. F. O'Marah,** manager of business branch, **W. S. Micchelli,** manager of operations branch.

James Guardia, formerly design engineer with Jacuzzi Pump Co., has joined the design group at Tinsley Laboratories, Inc.

Mercast Manufacturing Corp. has announced appointment of **John Weaver,** former chief project engineer for B. H. Hadley Co., as director of customer relations, succeeding Michael Gladstone.

Tudor A. G. Randell has joined the staff of Dr. Peter A. Castruccio, Technical Director of Aeronca Manufacturing Corp.'s Aerospace Division, as chief electrical engineer.

Avtron Manufacturing, Inc., has appointed **Arthur F. Pelster,** formerly a vice-president of Leland Electric, vice-president-sales, and **Ruben Kazarian,** prior assistant chief engineer at Ohio Crankshaft, chief engineer.

E. M. Armstrong, formerly with Coleman Engineering Corp., has been chosen director of customer relations for the Electric Machinery & Equipment division, American Electronics, Inc.

Republic Aviation Corp., has announced two special administrative appointments: **Richard G. Bowman,** who has served the company in a number of executive engineering posts since 1935, has been made technical assistant to the president, and **Carver T. Bussey,** special assistant to the president.

Russell J. Jameson, formerly with Foote Brothers Gear & Machine Corp., has joined Dalmo Victor Co. as manager of the methods and industrial engineering department.

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Develop procedures and methods for use of electronic test equipment. Assist supervision with manufacturing problems. Investigate malfunctioning of electronic equipment off and on aircraft. Prescribe corrective action. Make recommendations in methods and procedures as may be required to meet new developments in the electronic fields.

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OPTIMUM FREQUENCIES FOR OUTER SPACE COMMUNICATION, Army Radio Frequency Engineering Office, Washington, D.C. Order PB 151629 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 33pp. $1.

This report has been compiled as a preliminary investigation to provide Army frequency officers, engineers and project officers with a general appreciation of the propagation and frequency aspects of space communication as known to date, and to provide a point-of-departure for further study and discussion of this subject.

A further detailed study directed solely to radio propagation aspects is under preparations.

THE CORROSIVITIES OF PLASTICS AND RUBBERS, H. A. Perry Jr. and others. Order PB 151750 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 41pp. $1.25.

Studies confirmed that some plastics and rubbers can corrode metals in humid surroundings. The cause appeared to be the release of electrolytes which are dissolved in water films and droplets on metals surfaces in concentrations heavy enough to bring galvanic corrosion.

In a few materials, volatile electrolytes such as ammonia and hydrogen are released. The most corrosive plastics and rubbers apparently are phenolic molding compounds, foams, and casting resins. Those containing cellulosic fillers appear worse than mineral filled phenolics.

Also corrosive are chloroprene rubbers, suffer-vulcanized GRS rubbers, poly esters, vinyls and halocarbons (under thermal degradation), and the two-step phenolics.

Three techniques for testing corrosivity are described. The best, which permits identification of water-soluble ionic constitutents which contribute to galvanic corrosion, is recommended for use with thermosetting or thermoplastic organic resins, inorganic or organic plastic fillers, laminates, adhesives, and natural and synthetic rubbers.

TENSILE PROPERTIES FOR THREE THERMOPLASTICS OVER SIX DECADES OF RATE, R. E. Ely, Redstone Arsenal, U.S. Army Ordnance Corps. Order PB 151573 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 75p, $2.

Tensile properties for ethyl cellulose, and polymethyl methacrylate are reported for testing machine crosshead velocities of 0.02 to over 5000 in/min.

Polyethylene data are given for a slightly smaller range of velocities. Fracture times varied from a few milliseconds to hundreds of minutes.

A pneumatically operated, high speed machine and a standard tester were used. Temperature ranged from –76 to 158°F, with a few tests as low as –320°F.

The range of tensile strengths in one case was over 1000%. Brittle points were found to high rates and low temperatures. Included are some data for ultimate strains and elastic moduli.

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A Captive Small Business?

There are probably more misconceptions about Small Business and the role it plays in the defense industry than there are concerning almost any other field of American business.

Unfortunately a great deal of this misconception is in the minds of the Congressmen who will come up at the next session with a number of proposals, some or any of which may be enacted into laws covering the Small Business field.

The great danger is that any laws passed under these misconceptions may not, in the long run, aid Small Business. They are, however, very likely to make Small Business, or that portion dealing in government contracts, actual captives of the government.

Let's take a look at some of the erroneous notions which have been carefully fostered:

1. Competent Small Business prefers advertised bids.
2. The negotiated bid is a pretty shady operation and usually results in favoritism.
3. Government buyers use negotiation to exclude the little guy; it's a device to favor the big primes.
4. Advertised bidding means that everyone is being treated fairly and automatically means also the lowest cost to the government. (Also that non-defense industrial buying is usually done by advertising.)
5. By ignoring learning curves, tooling problems—that the Defense Department is to blame for not getting all design data from the R&D phase of a weapon system so competitive bids may be let for subsequent production.
6. That government money pays for the design of all components of weapon systems, hence these designs belong to the public.
7. That the Department of Defense favors the big primes by design, that the weapon system is a result of this, and that big contractors will automatically try to retain component making in order to keep all the money in the house.

Actually, none of the above points is true, or true to any important degree, but who can make this fact known to Congress?

Big Business can't do it. As someone has said, Big Business is automatically considered to be self-serving—and a little too rich to be honest.

This leaves Small Business, itself. And Small Business is really the one to do it, because small manufacturers stand to gain or lose the most if new laws tend to make them captives instead of free competitors.

The average Small Businessman is a pretty rugged individualist. He had to be to start and to survive. Also, he is a busy man and the more successful he is, the busier. Normally, he has neither the time nor the inclination to go to the Small Business Administration or to his Congressman.

If you ask him individually, he doesn't want or expect to be favored in price over anyone. He doesn't like the principle of renegotiation any better than the big prime. He isn't very keen on going to the SBA for help. He *doesn't* favor the advertised bid over the negotiated bid. And, above all, he doesn't want a direct government contract. He usually hasn't the capital to handle it and, more important, he wants to protect the proprietary rights to the components he develops himself. He would much rather be a subcontractor.

But he is the man who is going to have to tell this to Congress—or to the Congressional staffs which usually draft the proposals—if he doesn't want to face the alternatives. These include SBA participation in prime contract negotiations; SBA influence in subcontract source selection; giving government agencies greater power in "make or buy" decisions or placing an SBA representative in prime plants for that purpose.

We can't quite believe that the responsible Small Businessmen want this degree of socialism, control, government supervision or what have you thrust upon them by act of Congress. We can't believe they want to be captured and reduced to the lowest or even mean level of competency. But they are the ones who are going to have to communicate this to Congress. It's election year and "Aid to Small Business" is a nice nebulous phrase that sounds good in a stump speech.

CLARKE NEWLON

He put a new twist in an old trick

His problem was to take a 3"x6"x 3-foot piece of wave guide tubing made of .08-inch thick aluminum and to twist one end 90° to the other *without buckling or stretching any part of it . . . so that a cross section taken anywhere along its length remained a perfect rectangle.*

The standard solution for a problem like this: Support the tube internally with a solder-like substance that's melted in, cooled, melted out after twisting. It won't work here because the mass of the substance is too great.

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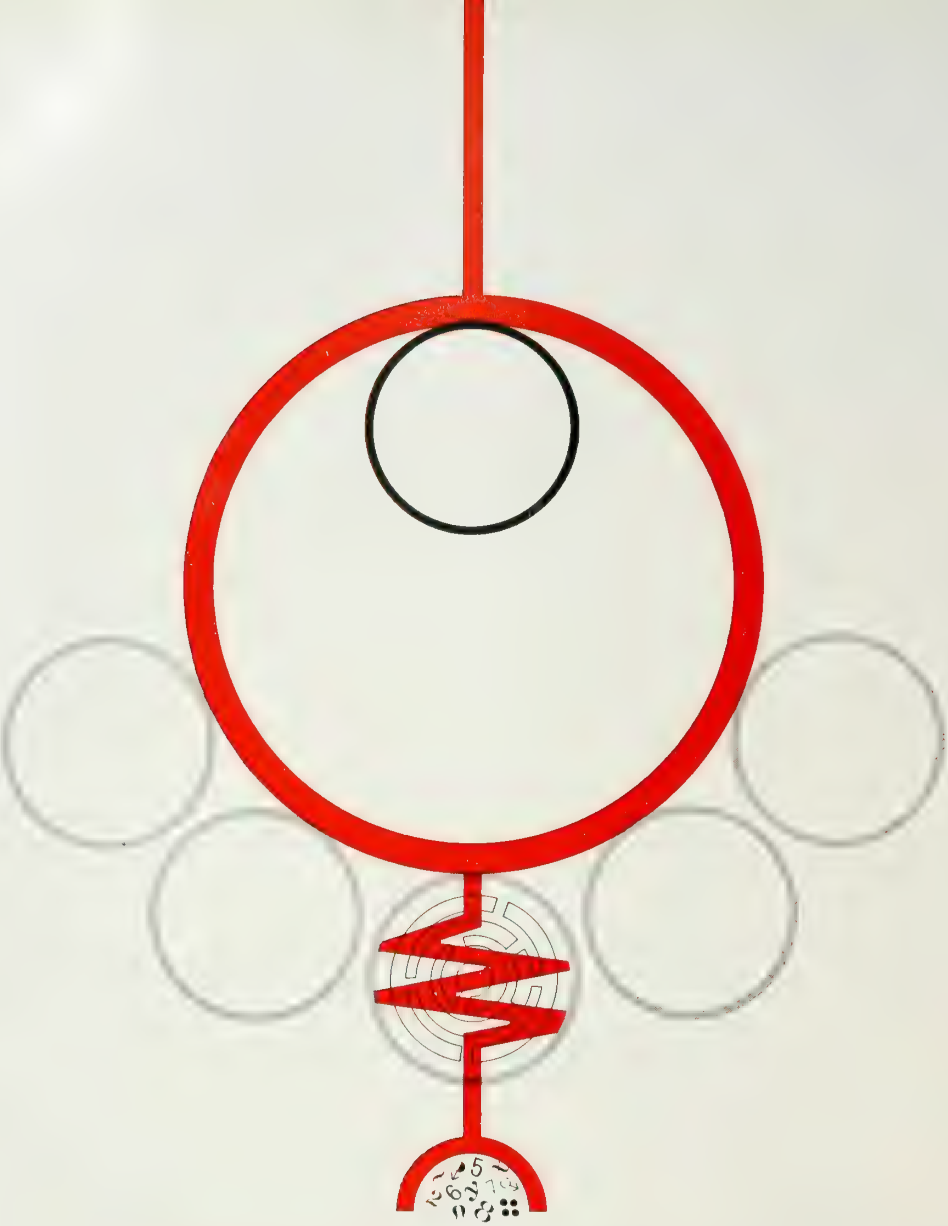

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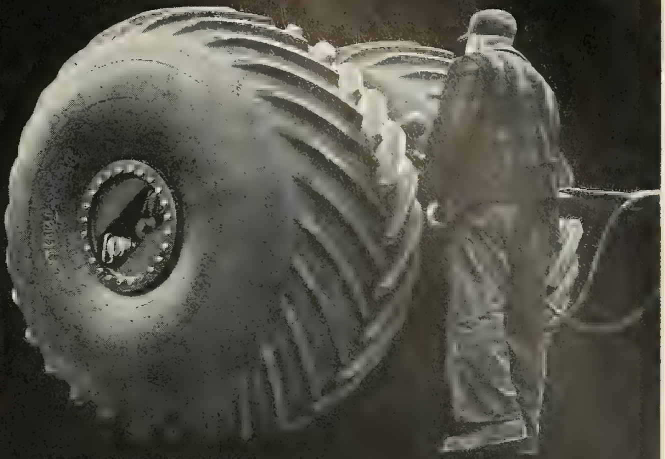
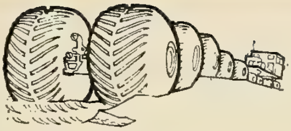


Here—from Goodyear—are ingenious new rubberized containers that offer double dividends: lightweight liquid storage plus unmatched all-weather mobility.



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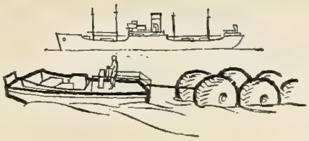

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—OR COMES BY AIR?

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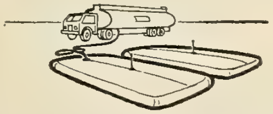

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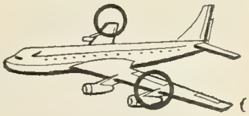

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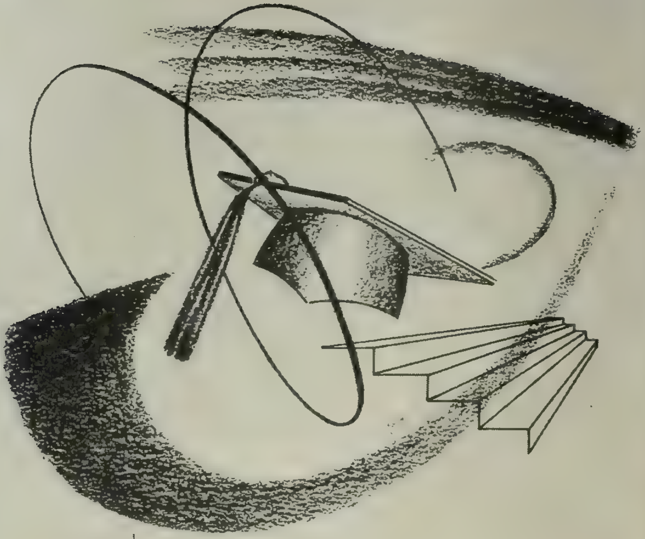

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missiles and rockets

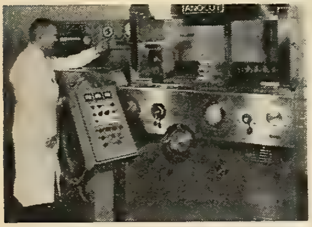
MAGAZINE OF WORLD ASTRONAUTICS

31,900 copies of this issue printed

COVER: Army's *Juno II* rocket carrying NASA's *Explorer VII* satellite into orbit rises from Cape Canaveral Oct. 13. The successful shot followed a failure with another *Juno II* on July 16.

GENIE WAITS on Douglas trailer for attachment to Northrop F-89J jet during recent William Tell II World Wide Weapons Meet at Tyndall AFB, Fla. See a report on the meet, pp. 14-16.

MISSILES are heated, quenched in water during simulation tests at one of the facilities of the Naval Weapons Laboratory at Dahlgren, Va. A report on NWL starts on p. 20.



ELECTROLYTIC cavity-sinking machine developed by Anocut. Work space is at right, drivehead mechanism at left. This advance is reported in machining story, p. 29.

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Saturn Switch Takes Military out of Lunar Space

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Near-combat conditions during William Tell II show at Tyndall AFB show value of weapons mix, but results don't reflect what would happen against real attacking planes carrying electronic countermeasures 14

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Washington Countdown

IN THE PENTAGON

An indefinite stretch out . . .
of the **Douglas** ALBM study program is underway apparently because of Air Force money shortages. **Douglas** originally was expected to have come up with a prototype model by November.

• • •

A possible substitute . . .
for the deceased **North American** F-108 in the "master plan" for U.S. air defense may be an advanced **Boeing** *Bomarc B*. Or, it may be modification of the **Boeing** *Minuteman*. (See this issue, page 16.)

• • •

Heating problems . . .
are believed to have caused the repeated failures in attempts to recover *Discoverer* capsules from orbit. Re-entry caused the capsules to become hotter than expected, creating an environment that their equipment was not designed to withstand.

• • •

New anti-radar missile . . .
called *Cobra* is being designed for the Navy. The missile will home on shipboard radiation.

• • •

The Air Force anti-radar missile . . .
program—known only as ARM—is now in the early study stage. The Air Force budget for FY 1960 includes more than $20 million for the project.

• • •

Fire control testing . . .
is being conducted aboard Air Force jets by launching missiles that never leave the plane. The job is understood to be done by a **Hughes** *Falcon*-shaped evaluation missile carrying equipment that automatically simulates the entire firing cycle from plane to target.

AT NASA

The NASA launching program . . .
for the remainder of the year includes:

. . . Two *Little Joes* carrying *Mercury* capsules.
. . . One *Atlas-Able* carrying a moon-orbiting satellite.
. . . One *Thor-Able* carrying a sun-orbiting satellite.
. . . One *Redstone* carrying a *Mercury* capsule down the Atlantic Missile Range.

The most dramatic shot scheduled for the early months of 1960 will be a repeat of the *Redstone-Mercury* launching only this time the capsule will be manned.

• • •

A billion-dollar budget . . .
or more has suddenly become a possible target for NASA for FY 1961 with the acquisition of the Army Ballistic Missile Agency all but assured. Previously, NASA had been expected to shoot for around $650 million.

• • •

Some of the reports . . .
heard around the nation's capital:

. . . Russian scientists are showing an increasing interest in Mars.
. . . The next class of U.S. astronauts will include a married couple.

AROUND TOWN

The new boss of ARPA . . .
is expected to be chosen within the next two weeks. The Administration is reported to be looking both inside and outside the government for Roy Johnson's successor.

• • •

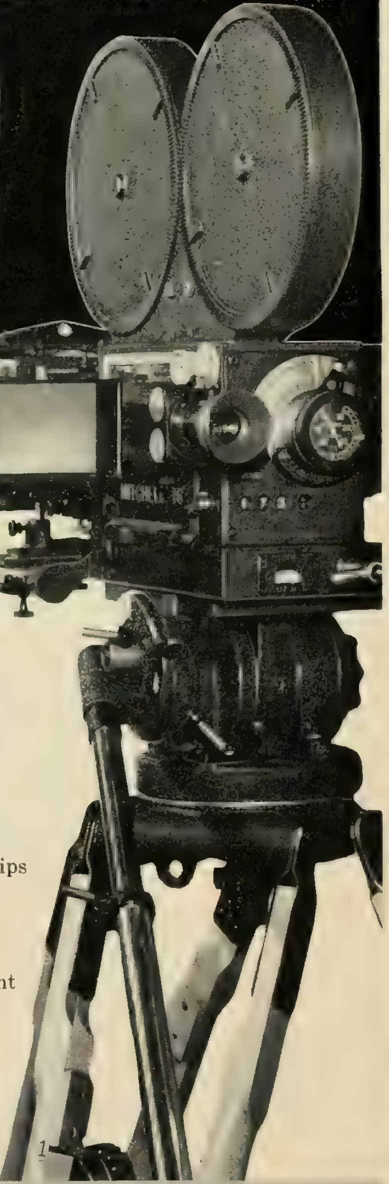
Sweden's STRILL-60 . . .
The Swedish Air Force's new semi-automatic operations control system for launching *Sidewinders*, appears to be a compromise between the U.S. SAGE and Sweden's outdated radar-human observation system. STRILL-60 is development of **Marconi's Wireless & Telegraph Co.** in England under an initial $4.25 million program. It will be used for surface-to-air as well as air-to-air missiles.

FIRST TRULY PROFESSIONAL 16MM MOTION PICTURE CAMERA

UNIVERSITY OF OKLAHOMA and Bud Wilkinson Productions use Mitchells; Director, Ned Hockman. (above)

BOB JONES UNIVERSITY set shows students and staff using Mitchell camera; Director, Katherine Stenholm. (right)

UNIVERSITY OF MIAMI TV-Film Department camera crew on location with their 16mm Mitchell; Director, C. Henderson Beal. (below)



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Industry Countdown

MANUFACTURING

Even if NASA funding . . .

increases substantially with the acquisition of ABMA, don't expect the space agency to hand out more R&D contracts. Reason: NASA soon will have a staff numbering more than 16,000 and a tremendous in-house capability. It will take a lot of work to keep them all busy.

• • •

Look for decision . . .

by Air Force on a contractor for *SLAM* (supersonic low-altitude missile) in February or March. **Convair, North American** and **Chance Vought** are competing for the airframe. All have study contracts.

• • •

Major opportunity . . .

may await manufacturer who comes up soon with VTOL aircraft capable of firing anti-submarine missiles. Navy reportedly is considering arming merchant ships with such a system to cope with the Russian undersea threat—which now numbers 450 subs.

• • •

Sea trials begin this week . . .

for the first *Polaris* FBM sub George Washington. Built by the **Electric Boat Division** of **General Dynamics Corp.,** the G-W is expected to attempt some pop-up tests of dummy missiles in the trials and to make its first live *Polaris* shot early next year.

• • •

New explosive forming . . .

process by **Ryan Aeronautical** can produce precise and intricate structures with little or no machining required for finishing. At the moment the shape, size, placement and type of explosive are a closely held company secret.

• • •

Expect the French . . .

to abandon their shipboard surface-to-air *Masurca* missile program, say U.S. officials. They will wind up either buying—or being given—*Terriers*. As in the IRBM field, the French want to make their own missiles. However, the experts believe the *Masurca* can't come close to the *Terrier*, and eventually they will have to drop it.

PROPULSION

Cesium supply problem . . .

as source for ion propulsion systems may be solved with the discovery of an extensive deposit of high-grade pellucite—an aluminum-cesium silicate—in Southern Rhodesia. **Bikita Minerals Ltd.** made the find.

• • •

Fluorine is now being . . .

researched as an additive to solid fuels. In solid state most of the nasty handling characteristics of liquid fluorine are eliminated.

• • •

Decision is in the works . . .

on the vehicle which will use a new liquid rocket engine being tested at NASA's Lewis Research Center. **Solar Aircraft** is fabricating thrust chamber and injector of brazed stainless steel. Regeneratively-cooled chamber is formed of 120 U-shaped AM-350 channels .008 inches thick, spot-welded, wrapped with .008 stainless steel ribbon and then brazed with copper.

ASTRIONICS

Moon-mapping . . .

capability is seen for high-resolution, three-dimensional radar being developed by **Goodyear Aircraft** on the **Martin** *Dyna-Soar* team. Big problem is still satellite power output inadequacies and antenna gains.

• • •

Thin-film research . . .

in microelectronics at **Motorola's** Phoenix, Ariz., facility is aimed at eliminating three out of four connections within the next five years.

WE HEAR THAT—

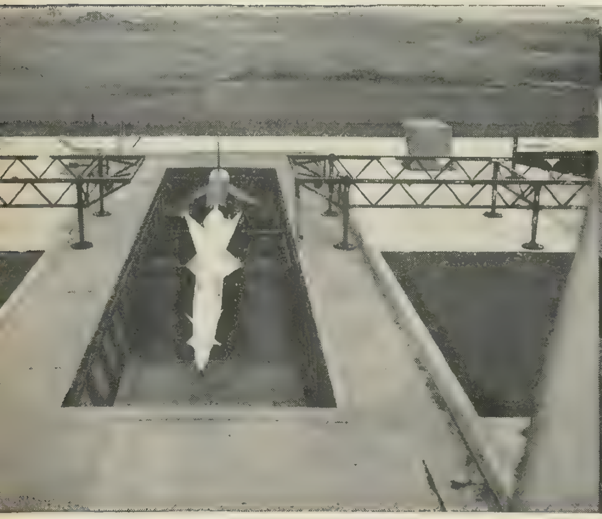
NASA may allow big sell . . .

of its *Scout* space probe vehicle to foreign nations starting this spring. The current price-tag is $500,000, but it could be obtained for less in volume orders . . . WADC has awarded **B. F. Goodrich** a development contract for a "unique, higher-thrust" solid rocket fuel . . . An underground R&D laboratory is being built at Anaheim, Calif., by **Nortronics** for advanced engineering studies of passive counter-measures rockets . . . **Temco** is estimating 1959 sales will be 40% from Space Age production compared to 26% in 1958 and 12% the year before.

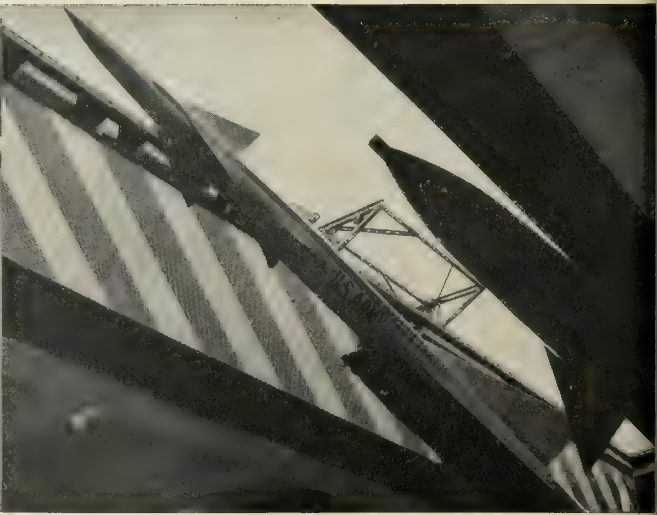
More About the Missile Week on Page 40.

About the earthly side of the Nike Ajax.

The U. S. Army's Nike Ajax is a strange but potent bird. Graceful, tough, packed with delicate instruments. He will fly only once in his lifetime—only in the event of an enemy attack. To launch him with split-second timing and accuracy, the Army puts most of its manpower and most of its materials into ground equipment. And virtually all the material required other than electronic equipment can be purchased from one firm—United States Steel. Whether you're talking about carbon steel, high-strength low-alloy, or ultra high-strength alloy steels, Stainless Steel, steel fence,



The Nike Ajax spends his days in a concrete and steel nest like this one. ICBM's will also live this way, but in nests that will take *thousands* of tons of concrete and steel. U.S. Steel specialists work continually with designers and construction engineers to find ways to use steel to its full advantage on such projects to build stronger with less materials . . . to build them faster.



It takes miles of wire and cable to rig a Nike nest. It will take *hundreds* of miles when bigger birds are put to roost. The Army uses many types of steel and steel products in a Nike nest. U.S. Steel conducts research and knows how to cut costs for any steel product used in ground support equipment.

electrical cable, cement or wire rope, United States Steel maintains the technical services to provide the proper assistance to cope with any problem on materials for ground equipment. When a ground support program goes to the drawing board, consult with

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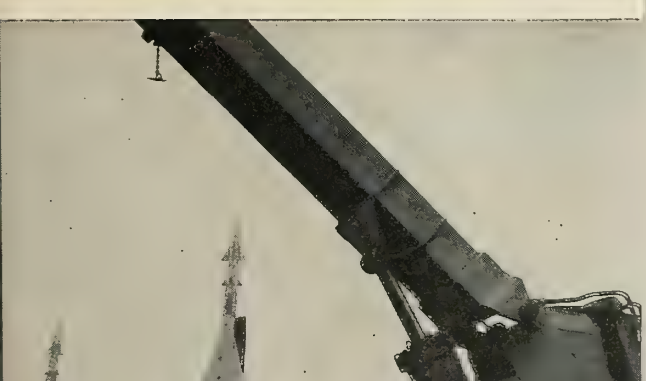
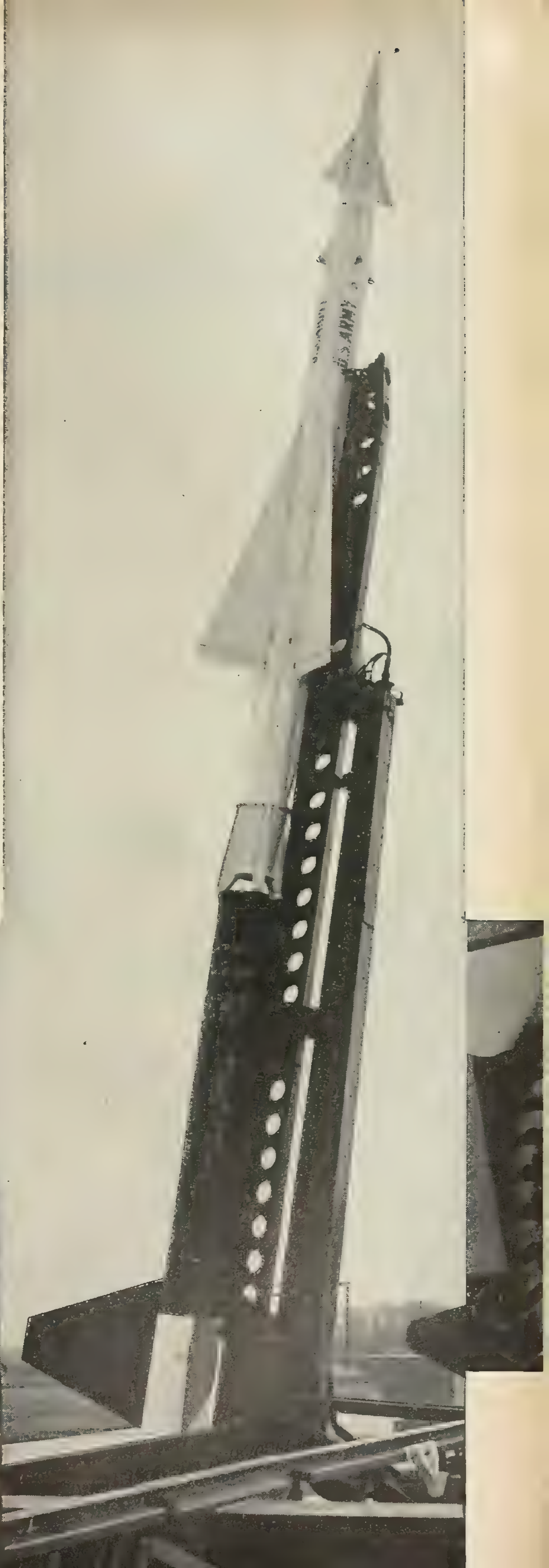


How light can you make a steel boom for any missile system without sacrificing strength? The proper selection of USS High-Strength Steels or Constructional Alloy Steels has cut the weight of similar equipment as much as ⅓—and *increased* the strength and service life.



Saturn Switch Takes DOD Out of Lunar Space Effort

Transfer of big rocket to NASA may commit the United States to becoming second-class military space power

WASHINGTON—The date of the transfer of the *Saturn* program from the Pentagon to NASA may go down in history as the point when the United States firmly committed itself to being a second-class military space power.

As of that date—probably early March—the Armed Forces will have no going program leading toward the conduct of military operations much beyond the edge of space.

It also will mark the end of the frustrating saga of a Pentagon attempt to make the United States a first-class military space power despite the hobbling restrictions placed on it by the Administration.

Saturn—the 1.5-million-pound-thrust clustered booster plus two upper stages—would be capable of placing 15-to-20-ton manned space stations into orbit and putting sizeable payloads on the moon. It is America's only foreseeable chance to overtake Russia's para-military space program in the early 1960's.

NASA conceivably could save the day by putting the *Saturn* program on a crash basis and planning for construction of dozens of the giant rockets for itself and the Air Force. However, unless there is a violent reversal of Administration policy, the chances of this happening appear thin indeed.

The current ARPA program for development of *Saturn* by the Army Ballistic Missile Agency has $70 million to support its operations in FY 1960. ARPA is expected to include about twice as much for *Saturn* in its new budget for FY 1961—a normal increase in line with the current development program. The same funding schedule would call for about $300 million for FY 1962.

Here are the past and estimated planned appropriations for the Saturn program under the current middle-of-the-road schedule and a crash schedule:

	CURRENT	CRASH
FY 1959	$ 34 million	$ 34 million
FY 1960	$ 70 million	$130 million
FY 1961	$140 million	$250 million
FY 1962	$300 million	$650 million

Under this program, a prototype of the three-stage *Saturn* vehicle would be ready for its first test flight in late 1963 at the earliest—nearly two years behind the original schedule. However, the funding rate of this program represents only a middle-of-the-road approach.

Officials generally agree that more than a year could be shaved from the program. To do it, the Administration would have to pump another $50 or 60 million into the program for FY 1960, about $250 million more in FY 1961—and follow that up with correspondingly bigger outlays in the next half-decade. The total cost could easily run to more than $1 billion.

Such a program would provide at least 30 to 40 *Saturn* vehicles—all of which must be planned for in the near future if they are to be available in the 1963-66 period. The first dozen or two probably would cost about $20 million each, the later models about $15 million.

The program also would include construction of a number of multimillion-dollar launching pads and static test stands for the giant rockets. The present program calls for construction of only one of each. This provides a built-in schedule of a maximum of about six launchings a year—and the built-in risk that if a vehicle explodes on the launching pad operations would be halted for months.

How far along this road NASA would be willing to fight its way is open to serious question.

NASA officials are extremely enthusiastic about the possibilities that have been opened up to their civilian space exploration programs by the transfer of ABMA and the *Saturn* program to their jurisdiction. They feel that *Saturn* will give them the capability to conduct major experiments on the moon and planets and deep space as well as to launched manned laboratory satellites.

However, it remains to be seen how far the Administration will go in allowing NASA to ask Congress for the big additional appropriations that would be needed to accelerate the *Saturn* program significantly. And NASA would develop and plan to build the *Saturn* vehicles that the Air Force would need for extensive military space operations only when the Air Force was able to begin funding the necessary extension of the *Saturn* program.

The Air Force has no money for such large-scale new funding now, and its chances of finding it in its large but pinched budget in the next year or so do not appear good.

Moreover, the Air Force has no assigned major mission at present to justify a big *Saturn* program because of the Administration's arbitrary division of space at 600 miles up.

Administration policy decrees that no military missions exist beyond that point. From 600 miles out, space belongs to NASA and the Russians.

It is to this 600-mile ban that the transfer of *Saturn* to NASA can be directly traced to a very large degree.

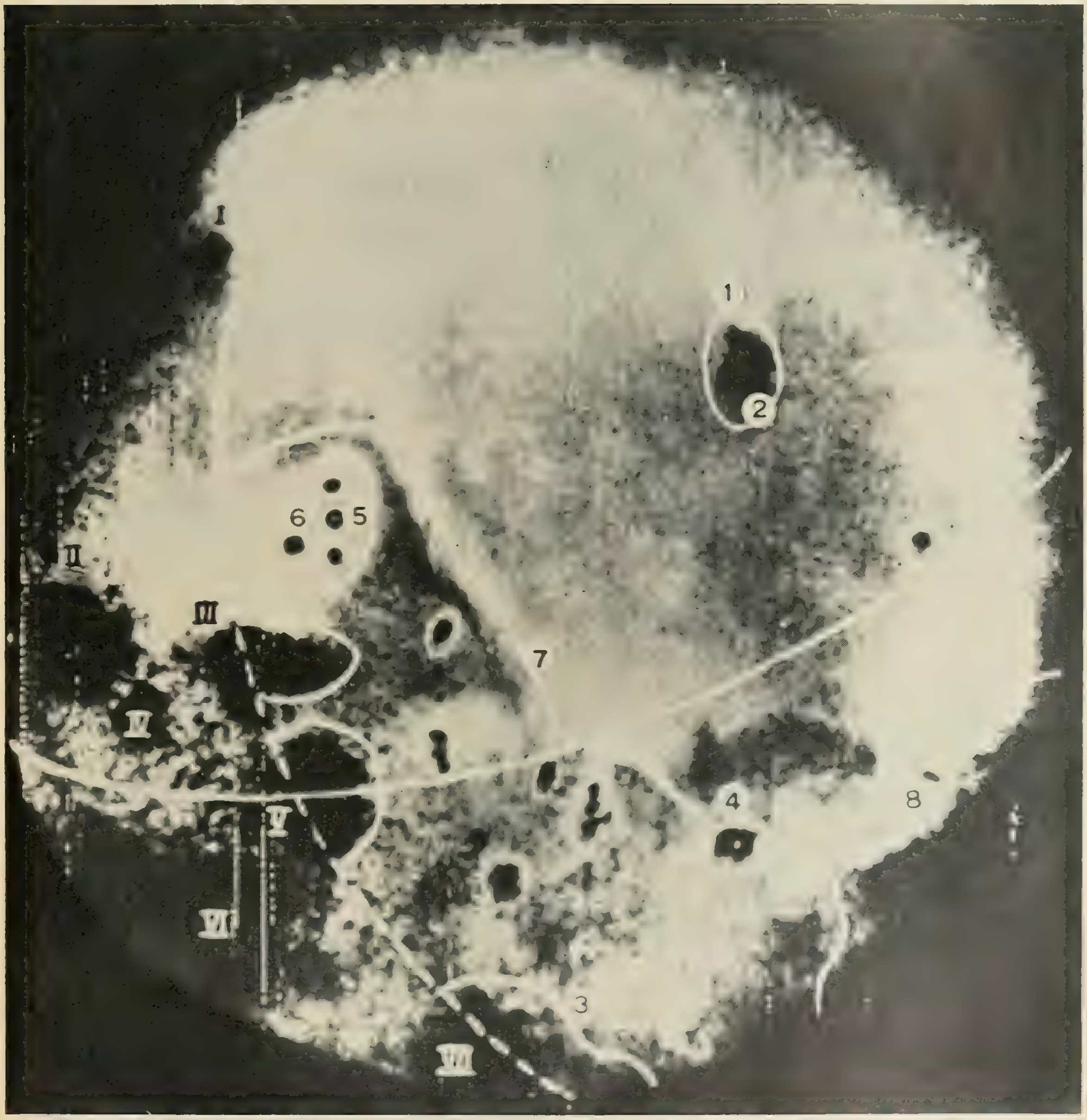
Because of the ban, ARPA has been justifying the *Saturn* program to the Budget Bureau since the program's inception in 1958 on the grounds that it would be used to boost large communications satellites into orbit about 1964 or 1965—not on the grounds that the military needed it to prevent Russia from dominating the moon and most of cislunar space.

In turn, the program has been transferred from the Pentagon on grounds that the Air Force can get no extra funds to support *Saturn* as a communications satellite booster—and can get no extra funds to support it as anything else.

Without question, the acrid smell in Pentagon corridors these days is caused by the smoke from the burning of the military bridge to the moon and space.

Red Photo Bears Out M/R Prediction

Lunik III photo released by Tass gives Arabic numerals to features on far side of moon newly named by Soviet astronomers: I—Moscow Sea; 2—Astronauts' Bay of Moscow Sea; 3—Continuation of South Sea; 4—Tsiolkovsky Crater; 5—Lomonosov Hill; 6—Joliot-Curie Crater; 7—Soviet Mountains, and 8—Dream Sea. Roman numerals on visible side of moon denote: I—Humboldt's Sea; II—Sea of Crises; III—Marginal Sea; IV—Sea of Waves; V—Smyth's Sea; VI—Sea of Fertility, and VII—Southern Sea.



The Russian photo shows basically what was predicted in M/R Feb. 16, in an article written by Contributing Editor Dr. I. M. Levitt, director of Fels Planetarium. Dr. Levitt said a "statistical look at the moon's other face showed that it would be wholly unlike the side we see from earth.

He assumed that there could be no large "sea" area—comparable to the visible Mare Imbrium—on the dark side, and that the other side therefore must be one of a few small "seas" and almost twice as many craters as on the visible side. This prediction was apparently well substantiated.

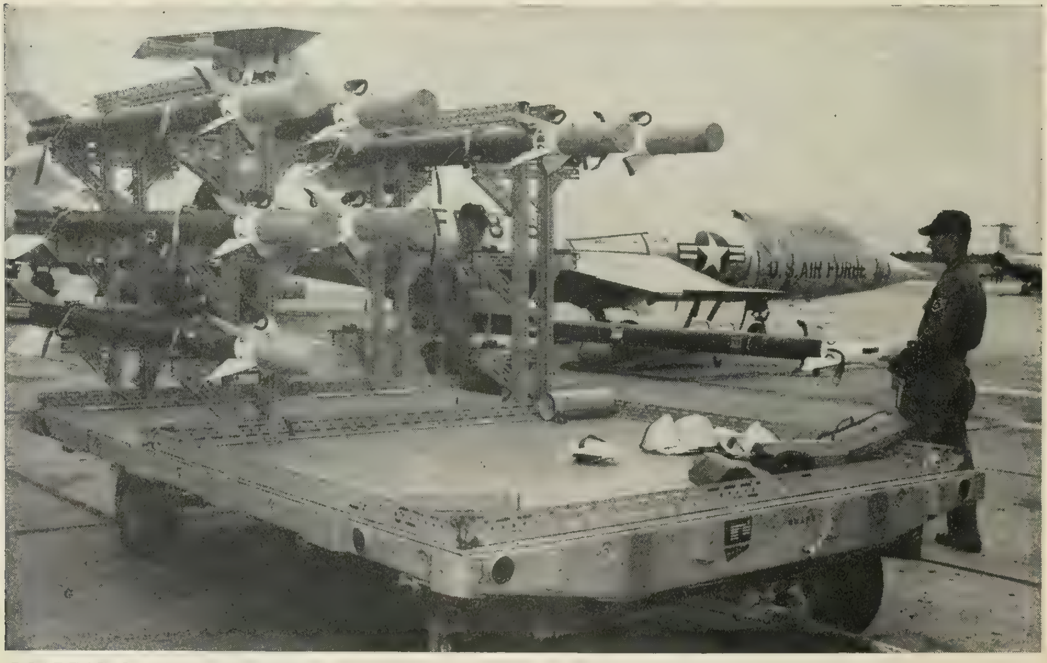
The craters don't show in the poor resolution of the photo, however, and what appears to be a smooth, drab plain is more likely to be pitted with craters, according to Dr. Levitt. Only the seas are prominent and the lack of detail fails to indicate the actual roughness of the far side.

←

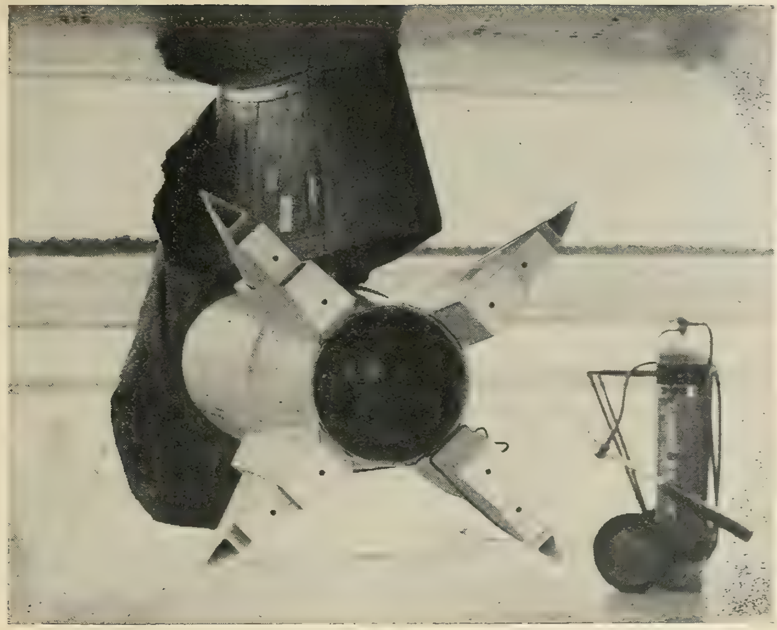
“THE ENEMY” Ryan Q-2A dron fished from the Gul Mexico after safely d ping there by parac

THE DEFENDE Douglas nuclear-head-packing *Geni* ready for action u wing of near-sonic N rop F-89J.

Missile Meet Tests Air Defense



LOADING GE-Philco *Sidewinders* **from racks transported to jet interceptors on a Convair flatbed carrier trailer.**



Near-combat conditions show value of weapon mix

The 10-day William Tell II World Wide Weapons Meet that ended Oct. 23 gave observers a detailed picture of the missile-striking power of the Air Defense Command. Here is a synthesis of that picture.

by James Baar

TYNDALL AFB, FLA.—You are at Ground Control Intercept at the William Tell II World Wide Weapons Meet.

This is a test under near-combat conditions of the ability of missile-packing Air Force interceptors to break up a bomber attack.

The GCI director waits patiently before his radar scope in the instrument-crowded room. Some 50 miles away out over the shimmering blue Gulf of Mexico a **Douglas** B-26 is dropping a near-sonic **Ryan** Q-2A drone. Suddenly the drone appears as a new blip on the GCI director's radar and he orders two supersonic F-102's into the air.

Minutes after the scramble, he and the pilots begin a staccato exhange:

Gold One, this is Rip Rap. How do you read?

Rip Rap, Gold One reads you five square.

GCI now is in complete control. He is the master tactician. The two **Convair** Delta Daggers, the **Hughes** *Falcon* missiles clutched in their bellies, the jet pilots are pieces on a board that he must move in a deadly game with the target. And so he begins.

Gold One, vector one five zero, climb angels thirty-five, go buster.

Gold One, roger one five zero, angels thirty-five, buster.

The Delta Daggers adjust their course and roar heavenward to 35,000 feet at full throttle. Meantime, the Q-2A *Firebee* drone enters on the hot leg of a racetrack-shaped course that will take it eight minutes to traverse.

The jets must make their pass and launch their *Falcons* during the eight minutes. This will be done toward the drone's tail in order to give the *GAR-2* heat-seekers a target. In combat, this would be the bomber's exhaust. In the meet, this is a flare attached to each of the drone's wing tips in order to conserve drones.

Gold One, target is measured thirty-two angles, tracking two five seven degrees, ground speed four-hundred knots.

The angle of attack depends on the missile. The IR heat-seekers—the *Falcon GAR-2* and the **GE-Philco** *Sidewinder*—must be launched so they can see the blast from the target's tailpipes.

On the other hand, the *Falcon GAR-1D* radar-seeker is launched toward the target's side. This provides a larger surface from which the interceptor can bounce the radar beam that the missile rides.

Finally, the **Douglas** nuclear-tipped *Genie* can be launched successfully at the target from any direction. The *Genie* is purely ballistic and—thanks to its nuclear warhead—doesn't even have to come very close.

In the meet, the **Northrop** F-89J's that carried *Genies* always launched them head on to keep targets from escaping. But this was done because the *F-89J* is only near-sonic. The Mach 2 **Convair** F-106 and the supersonic **McDonnell** F-101B which will be equipped to carry *Genies* will be able to launch them from any direction.

Gold One, target three o'clock position, range forty miles. You'll be turning shortly to your attack vector.

The decision as to which air-to-air missile probably will prove most effective at a particular time depends to a great extent on the weather and what countermeasures the enemy is able to employ successfully.

The Delta Daggers now speeding to their target will use *GAR-2* heat-seekers; the sky is clear and the *GAR-2's* can "see". If the weather were soupy, the *GAR-1D* radar-seekers would be used instead. This is why the load of six *Falcons* carried by the Delta Daggers is mixed.

Even so, both the heat-seekers and radar-seekers can be thrown off by countermeasures. But not the *Genie*: once launched, it is unstoppable.

Gold Flight, set speed Gate Two.

The Delta Daggers now cut in their after-burners and leap forward through the thin air with everything they have. In a matter of moments they will be in contact with the target with their own radars.

The 17-foot *Firebee* is only one-fifteenth the size of a Soviet Bison bomber. However, it is carrying radar reflectors that will make it appear on the jets' radar screens as almost a full-scale target.

Once the lead jet's radar is locked on the *Firebee*, the role of the GCI director in the attack is completed. The pilot and his fire control system will take charge.

Gold One, starboard turn to two four zero. Have you measured five *hundred feet low of target. When steady on two four zero you'll have your target at twelve o'clock, fifteen miles.*

Gold One roger, I have a contact.

• **No countermeasures**—Up to this point the operation is running fairly close to the way it would under combat conditions. The only major difference would be the substitution wherever possible of the GCI director by SAGE—the semi-automatic electronic system still under construction in many areas.

However, the GCI director and the jets are not having to contend with the countermeasures that they most certainly would have to contend with in combat.

All enemy bombers would carry ECM equipment that among other things would present the GCI director and the jets with a variety of targets only one of which would be the real thing. It would attempt to jam the GCI and jet radars, fouling their ability to track and fire accurately. And it would fire flares that would tend to deflect the heat-seeking *Falcons* and *Sidewinders*. All of this would be more or less effective against the various air-to-air missiles in the Air Defense Command's arsenal.

One way to reduce the effectiveness of countermeasures that are proving successful is to launch missiles visually instead of relying on the jet's computer. However, there is no question that the use of countermeasures still would cut down on the more than 80% kill scores made in the meet. Because of this, the next William Tell interceptor competition, scheduled for 1961, probably will have countermeasures equipment installed in the drones.

Two other factors not taken account of in the meet were the higher number of kills that are made possible by the firing of full loads of missiles rather than only one, and the loss of aircraft from enemy fire.

The danger of enemy fire was recognized in the approach maneuvers employed by the interceptors. However, the scoring system does not record whether the interceptor flies accidentally into the cone-shaped path of the enemy bomber's tailguns.

During the meet, scoring was recorded automatically by the **Parsons Co.** PARAMI system—a device for measuring the distance between the missile and the drone by monitoring the transmission of electronic pulses between them.

The new **Cubic Corp.** MATTS scoring system also was scheduled to be used, but technical difficulties prevented it from being put into operation. MATTS records the vector of the miss as well as the distance.

Gold One, we have you measured with target.

Gold One locked on at nine miles.

Roger, Gold One. Understand you locked on. Your target is measured two hundred feet high.

Gold One roger. I have a judy.

The pilot has now taken complete command of the interception. He does all the talking; GCI the listening. But even the pilot is mainly acting as a monitor and director.

Unless the pilot falls back on visual launching, he will not see the target when he looses his missiles on the enemy. His fire control system's computer will decide on the right moment and automatically pull the trigger. Then the pilot immediately will begin his escape manuever. This is particularly important in the launching of nuclear warhead-tipped *Genies*.

The meet provided a demonstration of the capabilities of all but two of the Air Defense Command's principal weapons—the **Convair** F-106 and the **Boeing** surface-to-air *Bomarcs*.

• **No substitute**—Both are able to deliver a nuclear punch and, since the sudden demise of the **North American** F-108 program, they share the role of the ADC's shortened front line of defense. So far, no plans have been announced as to what—if anything—will replace the F-108 and its advanced *Falcon GAR-9* missiles.

One possibility is that the Mach 3 North American B-70 will be given the dual role of interceptor and bomber. Another is that the range of the *Bomarc-B* may be extended to the 1000-mile reach that the F-108 would have had—or the *Bomarc* bases may be moved farther north into the Canadian Arctic.

Gold One fifteen seconds.

The pilot's voice is tenser. This is the payoff: Hundreds of thousands of man hours put into R&D, millions of taxpayers' dollars, years of training, it all comes down to this moment. He's roaring high over the Gulf of Mexico, but it could just as well be Hudson Bay.

The jet shrugs slightly as the missiles rip free and flash toward the target two miles away.

Gold One splash.

The voice is full of triumph. Death delivered by missile at 35 angels is his business.

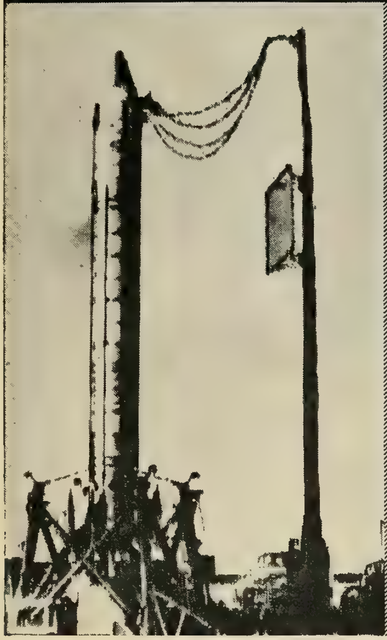
TYNDALL AFB—*The 10-day William Tell II Weapons Meet generally received a big hand as a demonstration of U.S. missile-airpower—except from two fun-loving Vermont mayors.*

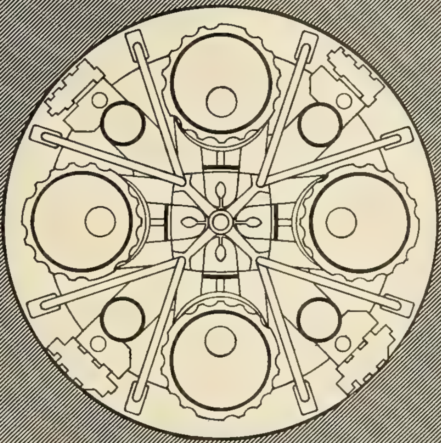
Mayor Dan Healy of Rutland and Mayor James Fitzpatrick of Burlington gave an unscheduled dash of bitters to the proceedings after a 24-hour run on the base, the officers club and nearby Panama City.

"Terrible waste," they complained as they checked their clinking suitcases on a plane for New Orleans.

COFFIN-SHAPED environmental containers made by Hughes are used for shipping each Hughes *Falcon* air-to-air missile from the factory to the airfield.

Gamma rocket engine delivers 19,000-lb thrust outside the earth's atmosphere—for a weight of under 700lb . . .





End view showing combustion chambers which can be inclined for vehicle guidance.

...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellent rocket engine, the Gamma delivers 16,400-lb thrust (7,438 kg) at sea level rising to 19,000 lb (8,618 kg) outside the earth's atmosphere for a total engine bay weight of under 700 lb.

The Bristol Siddeley Gamma has four gimbal-mounted combustion chambers which are hydraulically actuated for vehicle guidance. Each combustion chamber is fed with propellents by its own turbopump unit and the four units are joined at the centre by a common manifold. The Gamma burns hydrogen peroxide (HTP) with kerosene and uses silver-plated nickel gauze as a catalyst to decompose the HTP into oxygen and superheated steam.

Gamma powers Black Knight

The Bristol Siddeley Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. The Gamma has proved itself to be exceptionally reliable. In fact, in all firings to date Black Knight has never failed to start, and has reached a height of over 500 miles above the Woomera rocket range in Australia.

Since Bristol Siddeley's rocket division began work in 1946 it has developed a wide range of rocket components. By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to very high figures, can be met.

BRISTOL SIDDELEY ENGINES LIMITED

BRISTOL AERO-INDUSTRIES LIMITED, 200 INTERNATIONAL AVIATION BUILDING, MONTREAL 3, CANADA

Are Batteries Always Superior? Missile APU Manufacturer Says No!

Editor's note: The August 31 issue of M/R contained an article outlining a report made to the Air Force Ballistic Missile Division by Frank R. Cook Co. of Denver, concerning the relative merits of batteries as opposed to hot-gas units for missile auxiliary power. Sundstrand Turbo Division contends that some of the facts in the article based on the Cook report failed to give a complete picture and hence presented an unfair comparison of the two systems. M/R takes no stand in the controversy but here presents Sundstrand's rebuttal.

WASHINGTON—The controversial **Cook Co.** report is believed by some to have been a contributing factor in the Air Force cancellation of hot-gas auxiliary power systems for the *Atlas* and *Titan* ICBM's—a cancellation which affected **Sundstrand's** Turbo Division and **Aerojet-General.**

The report said use of a battery APU system would provide significant gains in reliability, and reduction in weight, costs, maintenance, personnel training, activation and checkout time, and spares and depot requirements.

Sundstrand takes exception to some of these claims.

The Sundstrand rebuttal is based, first, on the premise that the Cook report "compares apples and oranges" —the battery alone vs. the complete gas APU system. Sundstrand says that APU choice must be made for individual applications—no firm line can be drawn as to superiority of one over the other. It contends that for certain applications batteries would be the logical first choice; for others the gas unit is definitely best. Some of the parameters to be considered include power levels, space and weight requirements, operation duration, and type of desired outputs.

Sundstrand makes these points:

1) Requirements for an early operational ICBM dictated a design freeze on the *Atlas* which resulted in the choice of the battery power unit developed on a parallel program. Hot-gas APU development was on schedule with respect to reliability goals and BMD felt goals could be met. Lack of progress was not responsible for contract termination.

Design called for more than twice the energy capability of battery units now being used. Capability can be extended even beyond this point with only modification of tankage. Battery system beef-up requires design of entirely new components.

2) The Cook Co report was not responsible for switchover decision. It was compiled in July, 1959, some six months after decision was made.

(The report seen by M/R carried the date July 31, 1959. The report actually had been completed and presented to BMD in the last quarter of 1958.)

3) Development cost comparisons are unreasonable since the *Atlas* unit was designed on a crash basis—with consequent high costs. Battery development has been under way for 50 years.

4) Reliability of the gas-turbine APU has been proven. Considering complete systems, both are capable of meeting approximately 98% reliability requirement.

5) Sundstrand is now building for the Air Force an APU capable of producing power at extremely high efficiency for periods of up to several hours. Batteries to do the same job would be much too heavy to even warrant consideration. This program uses directly the technology gained in the *Atlas* development.

6) Reliability, weight, costs, and operational comparisons made in the Cook report are unrealistic, since only the battery is considered against total gas APU system—and necessary battery accessories (inverters, motors, pumps, etc.) ignored. On the basis of the total system the *Atlas* battery system weighs over 100 pounds more. The *Titan* battery unit is even heavier.

7) Gas-turbine APU's can be used in prelaunch checkout to check both the system itself and powered units. Use of batteries requires replacement and, hence, an unchecked unit in the fly-away missile. Replacement of batteries is costly and can drive system cost to several times that of gas systems.

8) Costs for training crews for APU maintenance were approximately $320,000 rather than the $1.5 million stated in the report.

9) Sundstrand furnished support equipment and services for *Atlas* maintenance. The prime contractor assumed responsibility for equipment and services required for battery unit. No comparison, therefore, can be made on this basis.

10) Comparison of activation times is unrealistic. Figures cited for the battery did not include the entire system. Activation time for the gas APU was less than AF specifications.

Sundstrand additionally makes the point that the change from bi- to monopropellant was a decision of BMD based on the AF effort to make *Titan* and *Atlas* units interchangeable. Both types performed satisfactorily in field tests.

Sundstrand also claims to now have an APU which meets almost identically the *Atlas* requirements and weighs under 50 pounds total—less than 20% of the current operational battery system.

Fuel Cells Deliver 15-kw Electric Power

MILWAUKEE—The first practical application of fuel cells to produce large amounts of electric power has been demonstrated here by **Allis-Chalmers Mfg. Co.** The propane-oxygen cells powered a 20-hp electric motor which drove a farm tractor, developing a 3000-pound pull. Total electrical output was 15 kilowatts.

Although still in the research stage, the unit is comparable in size and weight to an equivalent gasoline engine. Company officials feel that the size could be easily halved now and reduced still further in the future.

It offers a great possibility for space vehicle auxiliary power. Energy conversion in the cells produces no heat and efficiencies of up to 90% are possible (conventional steam turbines and diesel engines are about 40% efficient).

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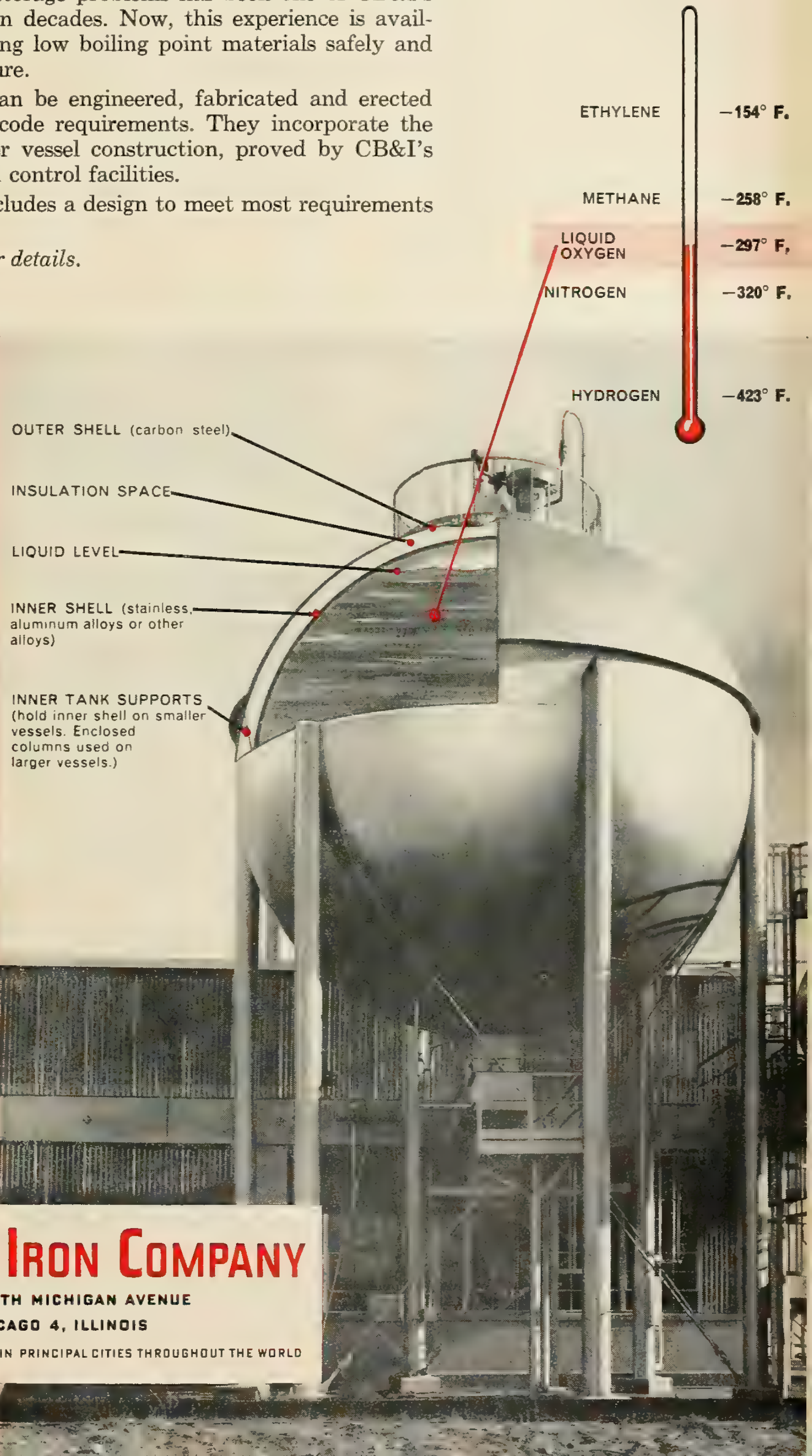
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INSULATION SPACE
LIQUID LEVEL
INNER SHELL (stainless, aluminum alloys or other alloys)
INNER TANK SUPPORTS (hold inner shell on smaller vessels. Enclosed columns used on larger vessels.)

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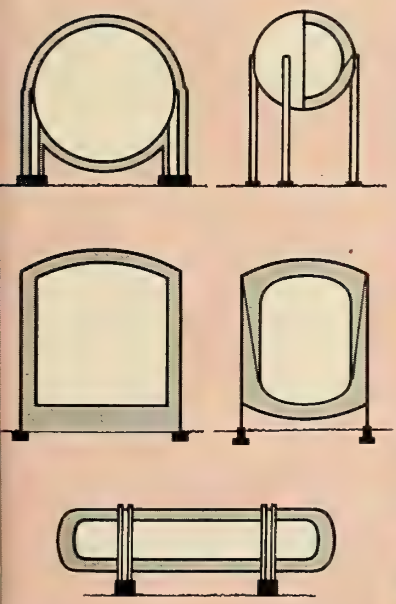

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Navy Saves Money on Missile Tests

Weapons Laboratory's short-cuts in testing and evaluation programs yield economies of millions of dollars and months of time in development

by Hal Gettings

DAHLGREN, VA.—Bargains are rare in the missile business. But the Navy says its Naval Weapons Laboratory here is saving the U.S. missile program several million dollars each year—and it backs the claim with hard facts and figures.

Work at the Laboratory covers a wide range of missile projects. Current are nose cone and re-entry research, capsule recovery, space surveillance, missile system management, missile safety, electromagnetic radiation hazards, warhead development, and rocket motor testing.

- **Nose cones and re-entry**—One of the principal money-saving projects at NWL was in the test of nose cone fuzes. As originally planned, the tests were to be conducted with a series of rocket-sled runs. By reversing the usual procedure and firing "targets" at the fuzed nose cones, a saving of approximately $2.5 million was realized on the *Atlas* program alone.

Using the world's largest gun—a 24-incher—total costs for eight shots ran less than $325,000 as compared to $2.8 million originally alloted. Much time also was saved.

- **Capsule recovery**—Approximately $300,000 was saved in a program to study recovery of data capsules from re-entry vehicles. The capsules, roughly the size of basketballs, contain recorders to log various aspects of performance such as acceleration, temperatures, pressures, and stress during re-entry. In actual firings of *Thor* and *Atlas* missiles, the capsule is separated from the nose cone and plummeted into the ocean; recoveries are few and very little information on design deficiencies is obtainable.

NWL engineers devised a method of firing the capsules down an instrumented track through a frangible plastic port into a water tank. Within minutes after firing, angle of impact and the condition of capsule equipment was available. An estimated 100 air drops would have been required to provide the same information. The program was completed in two months as against a year originally contemplated.

As a result of work done at the Lab, successful capsule recoveries have now become routine.

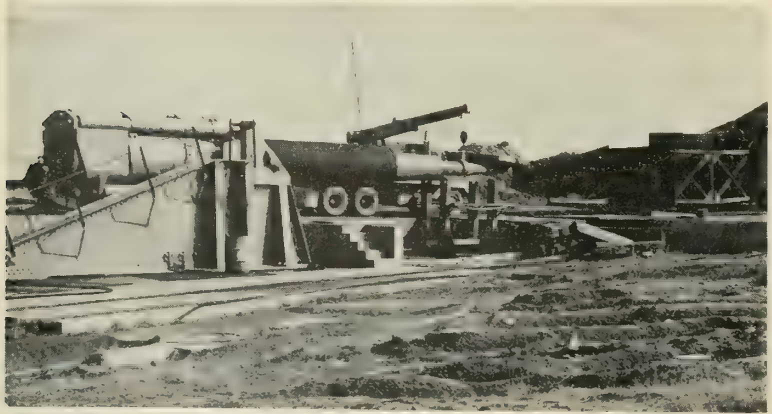
- **Warhead development**—Currently, NWL has major tasks in the development of warheads for five missiles, either in service or planned for service use in the near future. The Lab provides facilities for managing the program—from concept through fabrication of experimental models in its own shops to procurement and detonation of full-scale prototypes.

The first warhead development work assigned to NWL, just two years ago, was in connection with the *Bullpup* air-to-surface missile. As a result of its successful completion of the *Bullpup* warhead design, NWL in recent months has been assigned responsibility for developing warheads for *Talos*, *Tartar* and *Corvus*.

A primary aspect of warhead development is determination of fragmentation patterns. These tests utilize a "fragmentation arena" which measures patterns (space distribution), velocities, and forces of exploded warhead fragments. Facilities include both static and in-flight chambers and arenas where explosive charges of up to 600 pounds can be tested.

- **Missile safety**—NWL has had overall direction of the Navy's missile safety program for two years. A sizable group is developing safe handling and firing practices for *Terrier*, *Tartar* and *Talos* missiles. Facilities for test and evaluation include all manner of ignition, environmental, and test equipment. Missiles are dropped, heated, quenched and generally shaken up to establish safe procedures for shipboard handling.

- **Electromagnetic radiation hazards**—The Navy's program to define and eliminate hazards arising from exposure



WORLD'S LARGEST gun, a 24-incher, fires "targets" at nose cones to test missile fuzing and arming components. The Dahlgren base was founded 41 years ago.

ONE-FIFTH scale model is used for *Polaris* launch ejection tests, part of a unique managerial control system.

of missile ordnance to electromagnetic radiation has also been an NWL responsibility for two years. This work, carried on under Project *HERO*, has already produced significant results (M/R, Oct. 19).

- **Cartridge-activated devices**—Design and development of power cartridges for a multitude of aircraft and missile applications is a continuing program at Dahlgren. These miniature explosive power-packs serve such functions as stage and nose cone separation devices, valve and control operators, and self-destruct mechanisms.

- **Space surveillance**—The Navy's Space Surveillance Operation Center was located at Dahlgren earlier this year. It is responsible for detecting all satellites, transmitting or silent, which pass over the Navy's electronic fence extending from Georgia to California.

The heart of this system is the Naval Ordnance Research Calculator, better known as NORC. This computer, put in operation in 1955, is still recognized as the world's leading "electronic brain." It operates at a capacity of 15,000 operations per second. An operation may include addition, subtraction, multiplication or division, of 13 decimal digit numbers. Its high inherent speed and its 13-digit word length have enabled NORC to attack space satellite calculations with a speed rated at eight times faster than its nearest commercial counterpart.

- ***Polaris* program**—The Weapons Laboratory has played a significant role in development of the Navy's *Polaris* missile, scheduled to be operational next year. NORC was assigned major data processing responsibilities to help control highly diversified component production for *Polaris*. This program represents a unique managerial control of a large missile development program, with its hundreds of sub- and sub-sub-programs influencing one another in subtle and complicated ways. Its contribution enabled *Polaris* managers to exercise vastly improved comprehension and control of this hierarchy of events, allowing for modifications or alterations in plans as work situations developed, and applying additional effort just when and where needed.

Another important use of NORC has been in preparation of firing tables for *Polaris* missiles.

Until this summer, NWL was known as the Naval Proving Ground. Founded in 1918 on an isolated point on the Potomac 50 miles south of Washington, its function was to develop and test naval guns and projectiles. The advent of the missile age made the big guns pretty well obsolete, and the Proving Ground found itself without a need for its services in the new era. But, operating on the premise that missile and space vehicle performance is but an extension of the ballistic problems encountered in large-caliber shipboard projectiles, the Navy converted its extensive facilities at Dahlgren to work on these problems. Today they have a going concern involved in many aspects of missile research and development.

Present workload totals are more than $15.5 million, divided about equally among three major labs: computation and analysis, weapons development and evaluation, and warhead and terminal ballistics. This figure represents approximately a one-third increase over the previous fiscal year.

- **Facilities**—In addition to the facilities already mentioned, NWL has extensive laboratories, firing and launching ranges, test and measurement equipment, computation and data processing systems, and missile assembly and storage facilities.

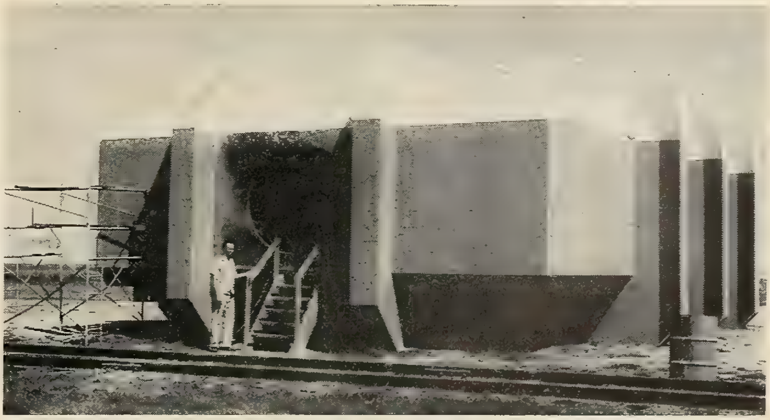
Several completely equipped firing batteries provide a wide selection of experimental conditions for firing guns, launching rockets and small missiles, reduced-impulse launching of larger missiles, and static tests of large missile boosters and sustainers. There are also emplacements for mounting launchers for flight testing small missiles and rockets; static firing stands for testing rocket motors, JATO units, and missile motors up to 300,000-lb. thrust; and a wide variety of altitude and temperature conditioning chambers for static test of igniters and actuators.

Specialized smoothbore guns are available with bore diameters up to 24" for firing non-spinning test missiles. The 24" gun is capable of firing modified bombs and guided missile warheads up to 5000 lbs. weight and at velocities up to 1300 ft./sec. Velocities up to 3500 ft./sec. can be obtained with objects weighing up to 1000 lbs.

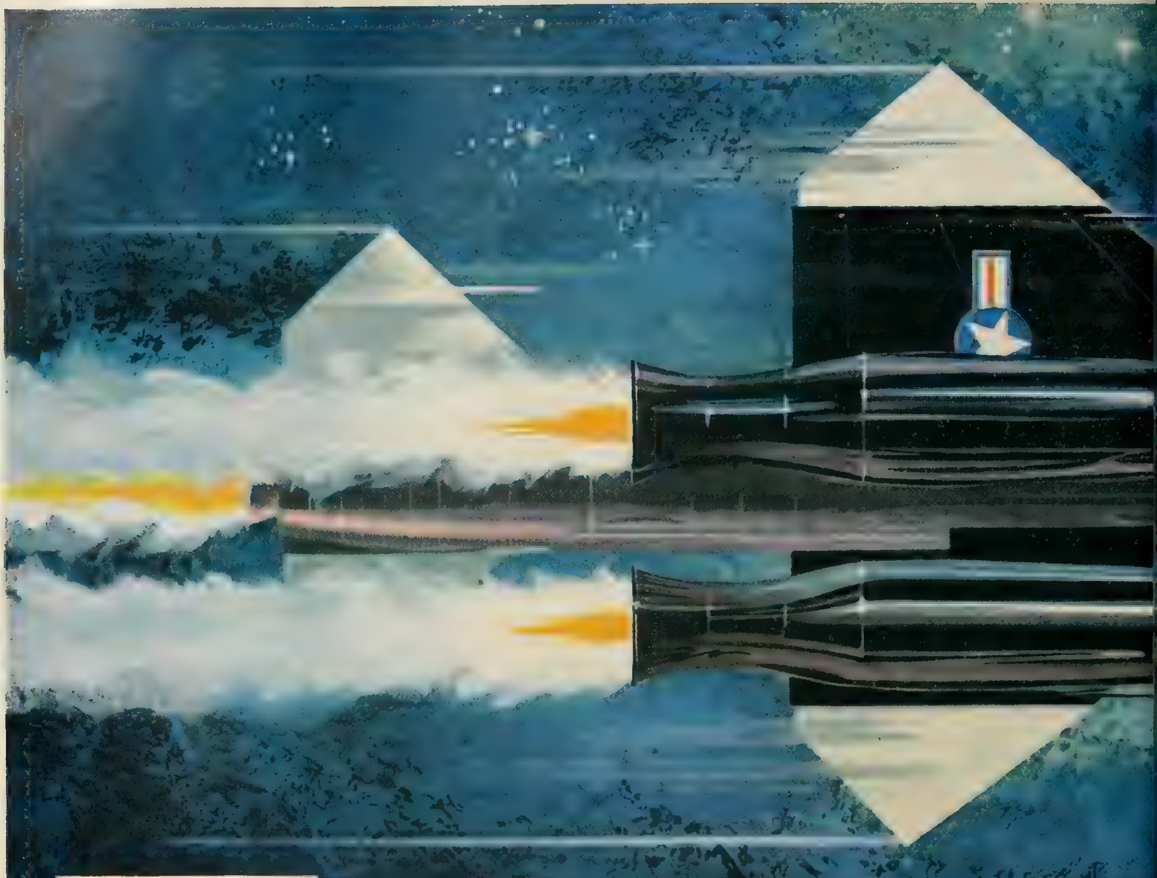
Other facilities provide for all types of hazard classification tests of explosive ordnance, including rapid heating by flame throwers, controlled heating to attain cook-off temperatures, 40 ft. free fall drop, detonation of pelletized explosives and warhead impact sensitivity.

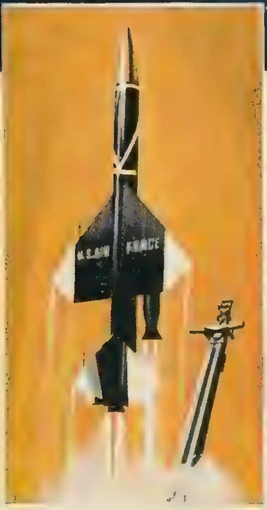
Several missile firing tracks—one 2500 feet long—with recovery tanks provide for the recovery of undeformed experimental projectiles and missiles for study of firing effects.

The value of the 5000-acre Dahlgren complex is estimated at close to $40 million. It is staffed by over 1400 military and civilian personnel—a large number of them mathematicians, physicists, and electronics scientists and technicians. This dedicated group feels that it is making a sizable contribution to the Navy's missile program—and saving a lot of money in the process.



SIMULATED shipboard missile magazine is used for damage evaluation tests of bulkheads, venting, sprinkler and drainage systems and for stowage safety tests.





Keeping pace with the nation's missil

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Solid-Fuel Technology Progresses

Reliable propellants in operation give I_{sp} ranging from 240 to 250 sec.; new gains occur steadily; ARPA expects 20-30 sec. quantum jump from Project Principia

by Jay Holmes

WASHINGTON—Whatever the status of other phases of the race for space, solid propellant chemistry is one area where America need not take a back seat.

The science has taken huge strides in the last five years—to the point where we soon will be powering our longest-range weapons with solids. Furthermore, we now hear serious proposals for building solid-propelled booster rockets of a million pounds or more of thrust for space exploration.

Reliable propellants in operational use today provide specific impulse between 240 and 250 seconds. We are testing and soon will be using several with more than 250 impulse. The 260 mark does not seem too hard to attain. Present lines of marginal development and improvement may even reach 270 without sacrifice of other desirable properties.

But in addition to this a quantum jump is expected from research in progress under Defense Department sponsorship. The department's Advanced Research Projects Agency expects impulse to rise 20 to 30 seconds in the next year or two as a result of studies under its Project *Principia*.

If the Soviet solid-propellant program has this much vitality, it has been an extremely well-kept secret.

The rapid progress in American technology has been a purely indigenous phenomenon. Most of the German scientists brought here after World War II confined themselves on liquid propulsion.

A major breakthrough shortly after World War II made possible the present state of the craft. Before that time, the size of solid propellant grains was rigidly limited. It was impossible to make a large propellant grain that would not collapse of its own weight.

But in 1946, a group at the **Jet Propulsion Laboratory,** California Institute of Technology, found a way to beat this limitation by bonding—or glueing—the propellant to the metal case. Before then solid propellant grains were inserted in the case after manufacture. Now it became possible to mold the grain in the case.

• **Rubber to rockets**—The JPL method made use of a class of organic compounds called the polysulfides, which had been used in the manufacture of synthetic rubber. These are long chains of atomic groups each containing a pair of sulfur atoms. A typical link in a polysulfide chain is shown in the accompanying diagram.

The polysulfide serves two purposes in the solid propellant grain. First, it acts as fuel. Second, its rubbery consistency holds the material together and makes it possible to bond the grain to the case.

It has one drawback, though. Sulfur, with atomic number 16, is a relatively heavy element. Its atomic weight is 32 times that of hydrogen. The two sulfur atoms in the polysulfide linkage add appreciably to the average molecular weight of the exhaust gases. This in turn reduces the average velocity of the gas molecules and thus the specific impulse.

For this reason, there was a continual quest after fuels without sulfur that have physical properties as good as the polysulfides. The solution was found in the early 1950's in the polyurethane family. Polyurethanes are composed of carbon, hydrogen, oxygen and nitrogen—all among the first eight elements of the periodic table. The accompanying diagrams show the two basic types of polyurethane links, the polyester and the polyether. Each is made up of combinations involving the basic urethane unit, which consists of two carbon atoms and one each of hydrogen, nitrogen and oxygen, also shown in diagram.

• **Argument on details**—Propellants containing the polyurethane fuels have specific impulse several seconds higher than those with polysulfide fuels. Although there is still some argument about details, it is generally agreed that polyurethanes can be developed with physical properties virtually as good as the polysulfides.

Meanwhile, development continued on another type of solid propellant, based on the nitroglycerin and nitrocellulose used in gunpowder and dynamite. Because of their relatively high impulse, these so-called double-base propellants were used in many small missiles.

About a year and a half ago, the Allegheny Ballistics Laboratory, operated for the Navy by **Hercules Powder Co.,** succeeded in case-bonding double-based propellants. This removed the rigid size limit.

At about the same time, a fourth type of case-bondable propellant entered the picture: the polyhydrocarbon. This is another class of rubbery fuel used with a crystalline oxidizer. A typical polyhydrocarbon linkage might be made by a reaction between an epoxide group, a combination of two carbons, three hydrogens and an oxygen as shown in the diagram, and a carboxyl group consisting of a carbon, two oxygens and a hydrogen.

Among the major solid propellant companies, **Aerojet-General** is usually considered a polyurethane producer and Hercules is commonly identified with double-base formulation. **Thiokol Chemical Co.** has a long history of working with the polysulfides but in the last few years has branched out into polyhydrocarbons and polyurethanes.

• **Hotter flames**—It was established several years ago that the addition of aluminum powder improves the performance of all solid propellants. Although aluminum increases the average weight of the exhaust gases by introducing aluminum oxide, (Al_2O_3) the flame temperature is increased even more. Since specific impulse varies with the square root of the flame temperature divided by the average molecular weight of the product gases, the overall performance is improved.

In the last year or two, all of these systems have been coming closer together. The double-base propellants have become composite propellants with the addition of oxidizer. Polyurethanes have been developed that are closer to the polyhydrocarbons. Polyhydrocarbons are being developed that are closer to the polyurethanes.

"All systems seem to be following converging lines of research," says Ernest S. Sutton, chief of research at Thiokol's Elkton plant. "The three we are working on are converging on polymers containing mostly carbon and hydrogen."

Aerojet sees the next big step in attaining higher specific impulse values and improved physical properties in the use of nitro compounds, an extension of the polyurethane family.

In nitro compounds, the nitrogen is bonded directly to an oxygen atom. In the normal urethane unit, nitrogen is bonded to carbon and hydrogen atoms. Aerojet's R. H. Hartman says specific impulse values in excess of 250 are expected from the nitro polymers.

What are the advantages and disadvantages of the competing systems in existence today? First, compare double-base with composite formulations of oxidizer and plastic fuel.

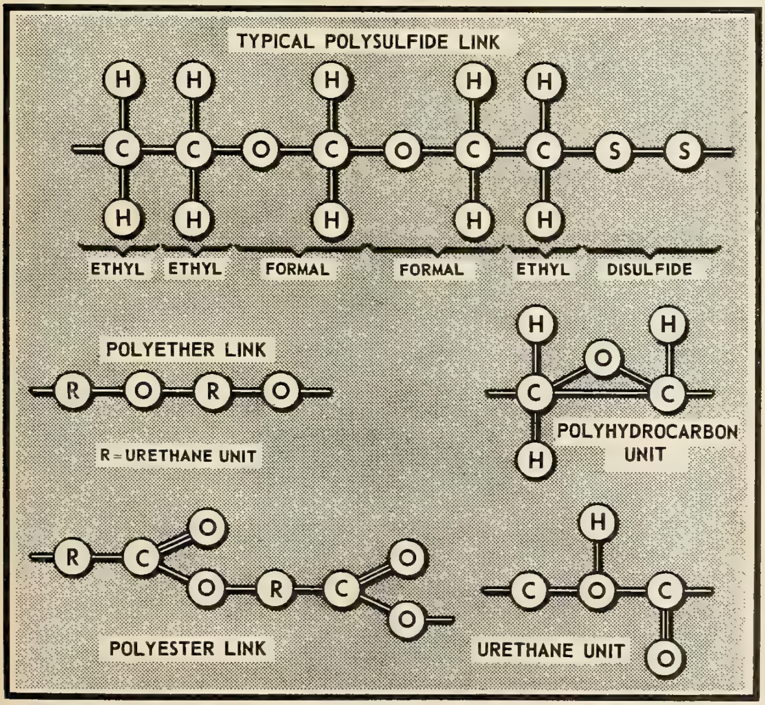
• **Unstable gases**—Hercules says it obtains a higher specific impulse with double-base propellants than has been done to date with composites. Thiokol's Sutton replies that double-base compounds are far less stable at high temperature than binder materials, the limiting link in the composites. They may ignite spontaneously when stored at high temperature. They may detonate during processing and during combustion. Sutton says this never happens with composites.

The Thiokol researcher emphasized, however, that double-base propellants are still valuable for many applications.

Among composites, there is a similar distinction in specific impulse between polysulfides on the one hand and the newer polyurethanes and polyhydrocarbons on the other. Thiokol says the difference is from two to five seconds. Aerojet says it is greater.

Why stay with polysulfides if there is a difference in impulse, however small? Sutton says there are three reasons: easier curing of the fuel, greater experience in dealing with them and better low-temperature properties. On the latter, he says the services customarily set requirements down to —75°F, at which polyurethanes tend to convert from a rubber-like to a brittle state. This in turn causes a solid-propellant grain to fragment and crack. More burning surface is exposed and, when it is ignited, the grain burns much more rapidly. The whole engine can explode in such a case.

Aerojet disputes all these points. Hartman says curing and handling of polyurethanes is quite simple. On production motors, he reports, Aerojet has produced polyurethane grains that operate satisfactorily at as low a temperature as —65°F. Furthermore, the Aerojet spokesman says polyurethanes have such advantages as lower cost, low viscosity and non-toxicity. He says polyurethanes are especially adaptable for large solid rocket motors because they do not engage in an exothermic reaction during cure. Hartman reports that aging characteristics of the polyurethanes are improving constantly. Today's propellants have ballistic and physical properties considerably improved over those produced two or three years ago, he added.



HERE ARE SOME common atomic groupings that appear in the organic polymers used as solid-propellant binders.

• **Secondary advantages**—What about the polyhydrocarbons? Sutton says thermodynamic calculations indicate they have exactly the same impulse as the polyurethanes. Polyurethanes have wider range of burning rates, he says, but polyhydrocarbons are superior in low-temperature and long-term aging properties. These secondary properties may be decisive when the range of burning rates is not a factor, he says.

In contrast with the disputes that swirl about the fuel binder in composite systems, there is little argument over the predominance of ammonium perchlorate as an oxidizer. Potassium perchlorate and the potassium and ammonium nitrates still are used but the industry is gradually dropping them. Ammonium perchlorate is cheap, light and the most effective oxidizer available. **American Potash & Chemical,** which produces virtually all of the ammonium perchlorate used in the industry, recently cut its price from 34 to 29 cents a pound.

For the propellants of the future, researchers supported by ARPA are trying to synthesize materials that do not now exist. "Potentially," says ARPA's Dr. Walter May, "materials that one can put down on paper are capable of producing a huge jump in specific impulse. Twenty seconds is the barest minimum. Much higher figures are stated in our documents with contractors."

The research is following many lines, he continued. There is a quest for better fuels, better oxidizers and better binders in the thermodynamic sense.

• **Lighter atoms**—Fuels can be improved, he said, by reducing atomic weights. This means getting more hydrogen into the system. Also, there must be continual efforts to reduce the number of relatively heavy elements.

How can oxidizers be improved? The chlorine in ammonium perchlorate has an atomic weight of 35.5. Fluorine,

(continued on page 43)

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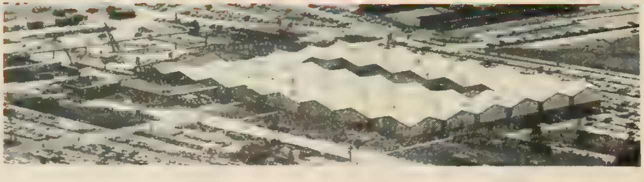

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I_{CBO}	Collector Reverse Current	$V_{CB} = 30v$	$I_E = 0$	—	1.0	μa
	at 150°C	$V_{CB} = 30v$	$I_E = 0$	—	100	μa
BV_{CBO}	Collector-Base Breakdown Voltage	$I_{CBO} = 100\mu a$	$I_E = 0$	60	—	v
BV_{CER}	Collector-Emitter Breakdown Voltage	$I_{CER} = 100ma$	$R_{BE} = 10$ ohms	40	—	v
BV_{EBO}	Emitter-Base Breakdown Voltage	$I_{EBO} = 100\mu a$	$I_C = 0$	5	—	v
h_{FE}*	D-C Forward Current Transfer Ratio	$I_C = 150ma$	$V_{CE} = 10$ v (2N696)	20	60	—
			(2N697)	40	120	—
V_{BE} (sat)*	Base-Emitter Saturation Voltage	$I_C = 150ma$	$I_B = 15ma$	—	1.3	v
V_{CE} (sat)*	Collector-Emitter Saturation Voltage	$I_C = 150ma$	$I_B = 15ma$	—	1.5	v
h_{fe}	A-C Common Emitter Forward Current Transfer Ratio	$I_C = 50ma$	$V_C = 10v$ f = 20mc	2.5	—	—
C_{ob}	Collector Capacitance	$I_E - 0ma$	$V_C = 10v$	—	35	μμf

*Pulse conditions: length = 300μs ; duty cycle ∠ 2%.

maximum ratings at 25°C ambient

Collector-Base Voltage	60v
Collector-Emitter Voltage ($R_{BE} = 10\ \Omega$)	40v
Emitter-Base Voltage	5v
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Total Device Dissipation at case temperature 25°C	2w
Storage Temperature Range	−65°C to +175°C

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The unique capabilities of Dow's Bay City, Michigan, foundry help users of magnesium sand and permanent mold castings. Activities at this facility—largest and best equipped of its kind—run the gamut from large volume production jobs to one-shot "specials".

Huge or tiny castings. The foundry is capable of producing castings weighing in excess of 3,000 lbs. down to ounces—in all degrees of complexity. Experienced pattern engineers ensure that the best use of casting processes is made. This can result in either lower costs, improved quality, better deliveries, or a combination of all three.

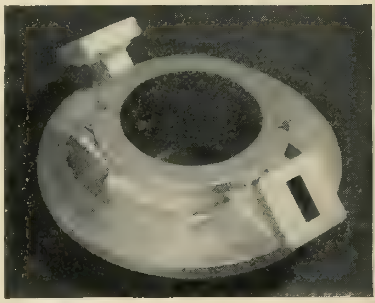
Newest techniques. Many milestones in magnesium casting have been reached at this Dow foundry. In fact, Bay City has men permanently assigned to developmental work, keeping the foundry in the forefront of technological advances at all times.

Results of their work include special processes for cast-in inserts and tubeless passages, and improved melting techniques. Casting methods have been developed for many of the newer magnesium alloys, such as the elevated temperature group and the new high damping capacity alloy, K1A.

Quality control. A full time quality control team exhaustively checks all work, from alloy composition to the shipping dock. A direct-reading spectrometer makes rapid alloy composition analyses. Its speed is particularly valuable when alloying elements that are hard to hold in the molten state, such as thorium, are present. Chemical analysis is also frequently employed.

Testing facilities. Molding and sand cores are analyzed as a regular part of casting quality control. Radiography, fluorescent penetrant inspection and other testing facilities are used to check properties and specifications.

Experienced magnesium team. The foundry often draws upon the broad range of specialized experience available throughout the company. To Bay City customers, this means assurance of high quality work, done with utmost efficiency and economy. If your requirements involve magnesium castings, Dow can help you arrive at optimum casting design and reliably supply your production requirements.



THIS SAND CAST WAVE GUIDE was held to ±.005" on passageway dimensions. Surface smoothness requirements are 63 RMS. The foundry has government approval for any phases of its operations where such approvals are applicable.

THIS BRAKE CARRIER is sectioned to show how the hydraulic lines were integrated by use of tubeless passageway casting techniques.

WRITE TODAY for this illustrated brochure discussing Dow foundry services. THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Sales Dept. 1303CL11-2.

THE DOW METAL PRODUCTS COMPANY, Midland, Michigan

DIVISION OF THE DOW CHEMICAL COMPANY

Circle No. 9 on Subscriber Service Card.

Revolution in Electrolytic Machining

Anocut engineers develop cavity sink device to meet metalworking challenge of Space Age—a report on this and other recent advances

by John F. Judge

WASHINGTON—A great deal of the debris littering the path to outer space consists of broken or worn-out drills, dies and cutting tools.

Since the Industrial Revolution, the task of machining and forming the products of the eternal quest for newer, stronger metals has been as much of a problem as their discovery—and very often, a serious limitation on the use of the metal.

A major contribution in this area is the recent development of a new electrolytic cavity sinking machine by the **Anocut Engineering Company**

Intended for use first in machining the high-strength metals used in missiles and jet engines, the machine can sink cavities of any shape into metals which resist ordinary cutting methods.

In operation, material is removed from the workpiece by passing a direct current continuously through a harmless, water-base electrolyte solution between the workpiece and the electrode.

Although Anocut electrolytic machining is widely used in industry, this device differs in that the electrode does not rotate but plunges linearly into the work material.

Roughly described as an electroplating process in reverse, the removal method does not involve high temperature and there is no metallurgical heat damage to the material. Since there are no sparks or arcs as in the electro-discharge process, there is no wear or erosion of the electrodes or tools. The removal method imparts a highly polished surface to many of the new high-temperature alloys and its accuracy is comparable to conventional drilling and cutting operations.

Total volumetric removal with the Anocut machine is dependent upon the capacity of the power supply used. Ordinarily, the total removal potential may be concentrated in a small area. Thus it is normally easy to remove 0.100 cubic inches per minute over an area of one square inch.

Several pieces may be machined simultaneously by multiple electrodes as long as the power capacity is not exceeded. Neither the thickness nor the length of the electrode affects the penetrating rate.

Other recent developments in missile metalworking extend from electronic tool guiding to extrusion processes. A brief survey of the field reveals this rapid growth, characteristic of industry's progress in meeting the ever-increasing technological problems of the space era.

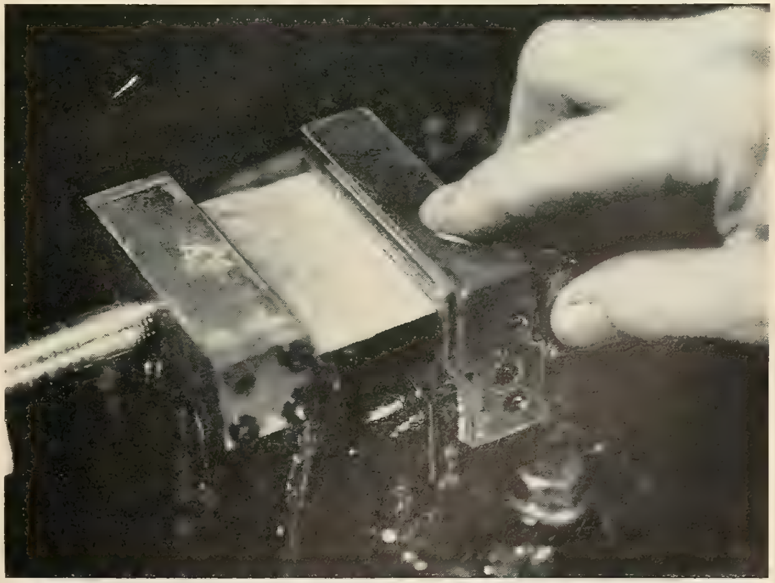
• **Automation**—Ten years ago a series of experiments were performed by engineers at the Massachusetts Institute of Technology on a Hydrotel milling machine. These efforts led to development of numerical control, a form of machine tooling automation.

The Cincinnati Milling Machine Company has applied this concept to many of their systems in the past decade, from the drawing boards to the finished product.

In all numerical controls, the basic bits of information that are fed into the control are really dimensions that define the location of points on the workpiece. These points are the essence of a positioning control—tool movement from point to point is relatively unimportant.

But where the points are used to define curves, the tool must be guided in the path it takes between points to produce the proper smooth curve in the workpiece.

Cincinnati's method of parabolic interpolation fits one curve with others in their system of contouring control. Such a control interpolates segments of parabolas between points on a curve, therefore requiring far fewer points,



ANOCUT'S electrolytic cavity-sinking machine forming a narrow slot with a knife-type electrode. Note that low heat permits operator to keep fingers on workpiece.

How Fansteel 77 Metal
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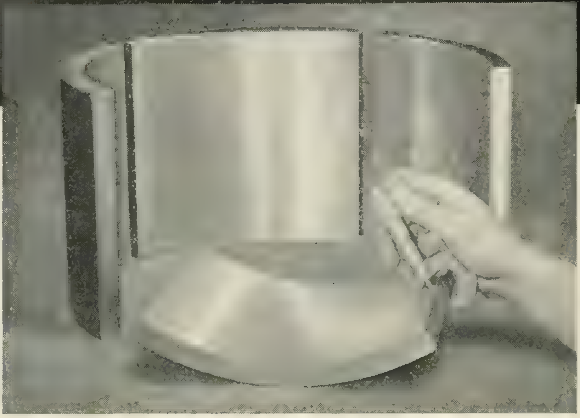

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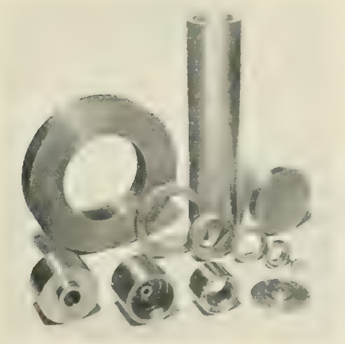

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and drastically reduces time consumed in plotting input information.

• **Form fabrication**—The Meta-Dynamics Division of Cincinnati Milling has concentrated on metalworking machines that employ controlled force rather than a grinding wheel or cutting edge to produce finished material.

Three of the Division's "chipless machining" methods utilizing controlled force are Cincinnati's Intraform, Hydrospin and Hydroform machines.

• The Intraform is the newest method for forming internal profiles. Hollow cylindrical stock is placed over a mandrel and kneaded by rapidly pulsating, rotating dies. The process results in high finishes and close dimensional tolerances. The metallurgical characteristics of the worked metal—such as hardness, tensile strength and fatigue failure resistance—are improved, largely through formation of continuous "flow lines" in the profile formed area.

Because the material is worked and kneaded rather than removed, less stock is required than in conventional machining. And the Intraform process performs in one operation what formerly involved several distinct steps.

• The Hydrospin machine involves a forming process in which a piece is forced to take the shape of a hardened rotating mandrel. The material revolves with the mandrel and the desired shape is spirally generated by one or two hardened and polished rollers.

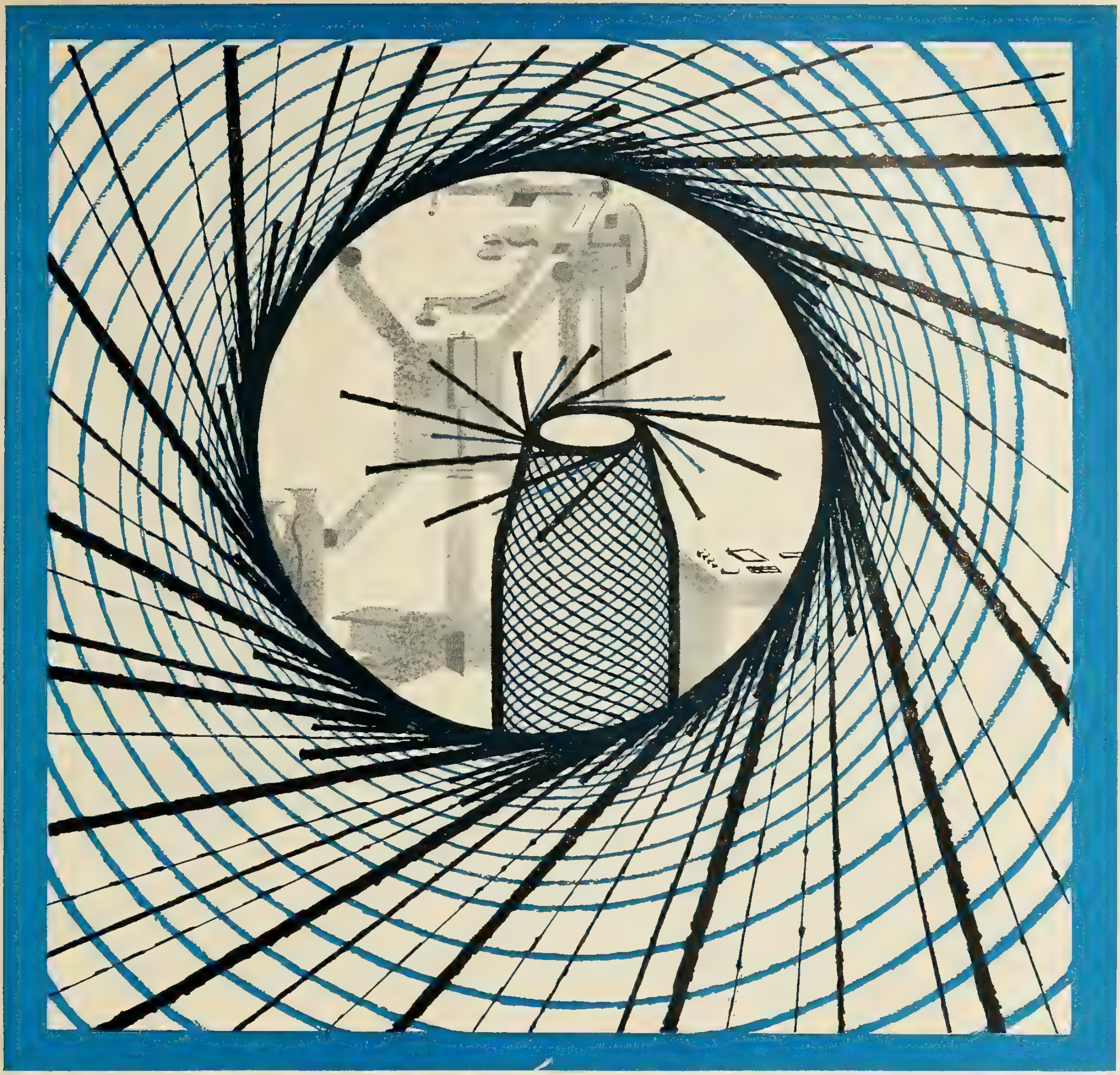
The deformation is usually done cold and, as with the Intraform, results in a work-hardened, tensile-strengthened product of high fatigue resistance. The Hydrospun part has no ruptures on its surface and its grain structure is greatly elongated.

Polaris engine case heads are formed by this method from a flat plate of 4340 steel. The result is a dished head 54 inches in diameter with finished wall tolerance of 0.150" ±0.007".

• Hydroforming is a simplified method of producing deep drawn shapes from sheet materials. The die and upper die holder of the conventional die set are replaced by a built-in, pressurized forming cavity sealed by a flexible diaphragm. This serves as the blank holder and as a universal die, accommodating any shape.

• **Extrusion research**—These processes will become more and more important as a means of producing required shapes for flight vehicles. The choice and use of a particular shape will be on the basis of pounds rather than tons, will involve shorter production runs and will consist of more complicated configurations than present structures.

The Manufacturing Methods Di-



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vision of the Air Material Command's Aeronautical Systems Center has been investigating development of the extruding capabilities of steel alloys and bare, pure beryllium.

In the steel extrusion program, the "H-11" grade (5% chromium hot work die steel) and the "A-286" temperature resistant ferrous alloy were chosen because successful extrusion of both would constitute a major advance in the art.

A "Tee" section 1.50"x1.50" with 0.06" thick legs was chosen as the typical shape. **Allegheny Ludlum Steel, Harvey Aluminum** and **C.I.E.P.M.** of Paris, France, participated and, at the end of a given period of time, each submitted samples of the steels and shape chosen to the **Northrop Corp.** for evaluation.

Both Allegheny and Harvey believed the goals possible with certain modifications in equipment and technique. C.I.E.P.M. went on record as stating the minimum thicknesses in the sample steels to be slightly greater than the 0.062" specified, but indicated later that research would lower the practical limits. While neither Allegheny nor Harvey was able to effect an extrusion in A-286, both extruded H-11, with Allegheny being the more successful.

Lyle M. Christensen of Northrop disclosed the conclusions of the initial phase of the program at the SAE Aeronautical Meeting in Los Angeles:

- Both of the alloys have definitely proven to be extruable to the stringent prescribed conditions—details remain to be worked out to establish consistency.
- The inadequacy of previous lubrication practices was established; strict adherence to present and amplified C.I.E.P.M. die lubrication techniques is necessary. There were several other conclusions regarding improvements in various components of extrusion presses.

Armed with this information, Allegheny began an extended development program. New equipment was fabricated and instrumented, and billet and die lubrication techniques were improved.

The A-286 was pushed successfully, but at a thickness of 0.093" instead of 0.062". H-11 was pushed at a lower temperature; the shape was excellent for 14 feet, before the die washed and the vertical leg was severed.

Both Allegheny and Northrop felt close to a breakthrough in the development of a technique to extrude ultra-thin steel extrusions. Allegheny was preparing for a full-scale operation in July, but the steel strike halted the effort.

(continued on page 43)

people

Maj. Gen. James McCormack, USAF (Ret.), vice president of Massachusetts Institute of Technology, has been elected a director of the Perkin-Elmer Corp.

McCORMACK

Gen. McCormack served in the Army from 1932 until 1949, when he transferred to the Air Force. He attained the rank of Major General in 1953, after having served as director of Military Applications for the Atomic Energy Commission, vice commander of the Air Force's Air Research and Development Command, and director of Research and Development, Hqtrs., USAF.

A graduate of the U.S. Military Academy, McCormack received advanced degrees from Oxford University and MIT.

Richard S. Leghorn of Itek Corporation has been named by Secretary of State Christian A. Herter to be top advisor on technical affairs to Disarmament Chief Charles A. Coolidge. He will serve on a part-time basis as a consultant until a joint State-Defense Department study is completed early next year.

Norvin E. Erickson will take over duties as base manager for Aerojet-General Corp.'s operations at the AF Missile Test Center, Cape Canaveral. He previously directed the Liquid Rocket and Component Test Department at Aerojet's Sacramento facilities.

Pieter van den Berg was elected president of Consolidated Electronics Industries Corp. Vice presidents will be: **Arthur W. Haydon, John Benita, Christopher H. Coughlin,** and **John D. Stout, Jr.**

Charles H. Webber has been appointed executive vice president of the Pacific Scientific Co. in a series of appointments following a merger with Pacific Aeroproducts. **Melvin H. Kennedy** moved into the position of secretary-treasurer.

WEBBER

Webber's duties include supervision and coordination of all activities of the company's Industrial and Aeronautical Divisions. His headquarters will remain in Los Angeles.

Other new PSC appointees were **Andre W. Reichel,** vice president of the Aeronautical Div., and **Leo A. Pfankuch,** vice president in charge of the Anaheim Div.

John M. Wild, developer of a three-dimensional boundary layer theory of aerodynamics, will join General Dynamics Corp.'s General Atomic Div. as director of Project *Orion,* and also become assistant director of the division's John Jay Hopkins Laboratory for Pure and Applied Science in San Diego.

Dr. Karl G. Kessler will head the Spectroscopy Section of the National Bureau of Standards. He will direct work in interferometry, analysis of spectra, and the study of hyperfine structure and isotope shift in spectra.

Brig. Gen. Benjamin S. Kelsey, USAF (Ret.), has been appointed Visiting Jerome Clarke-Hunsaker Professor of Aeronautical Engineering at the Massachusetts Institute of Technology for 1959-60. Since his retirement from the Air Force he has acted as engineering consultant for a number of industries.

Dr. D. S. Taylor, vice president of the U.S. Borax & Chemical Corp., has been named president of its subsidiary, the U.S. Research Corp. He has been with the company and its predecessors for 14 years in various research and development capacities.

TAYLOR

Dr. C. L. Randolph will be in active charge of operations at the facilities at Anaheim, Calif., as the new vice president of the Research Corp. He holds a Ph.D. degree from the University of Southern California and was associated with Aerojet-General Corp. before joining the company in 1957.

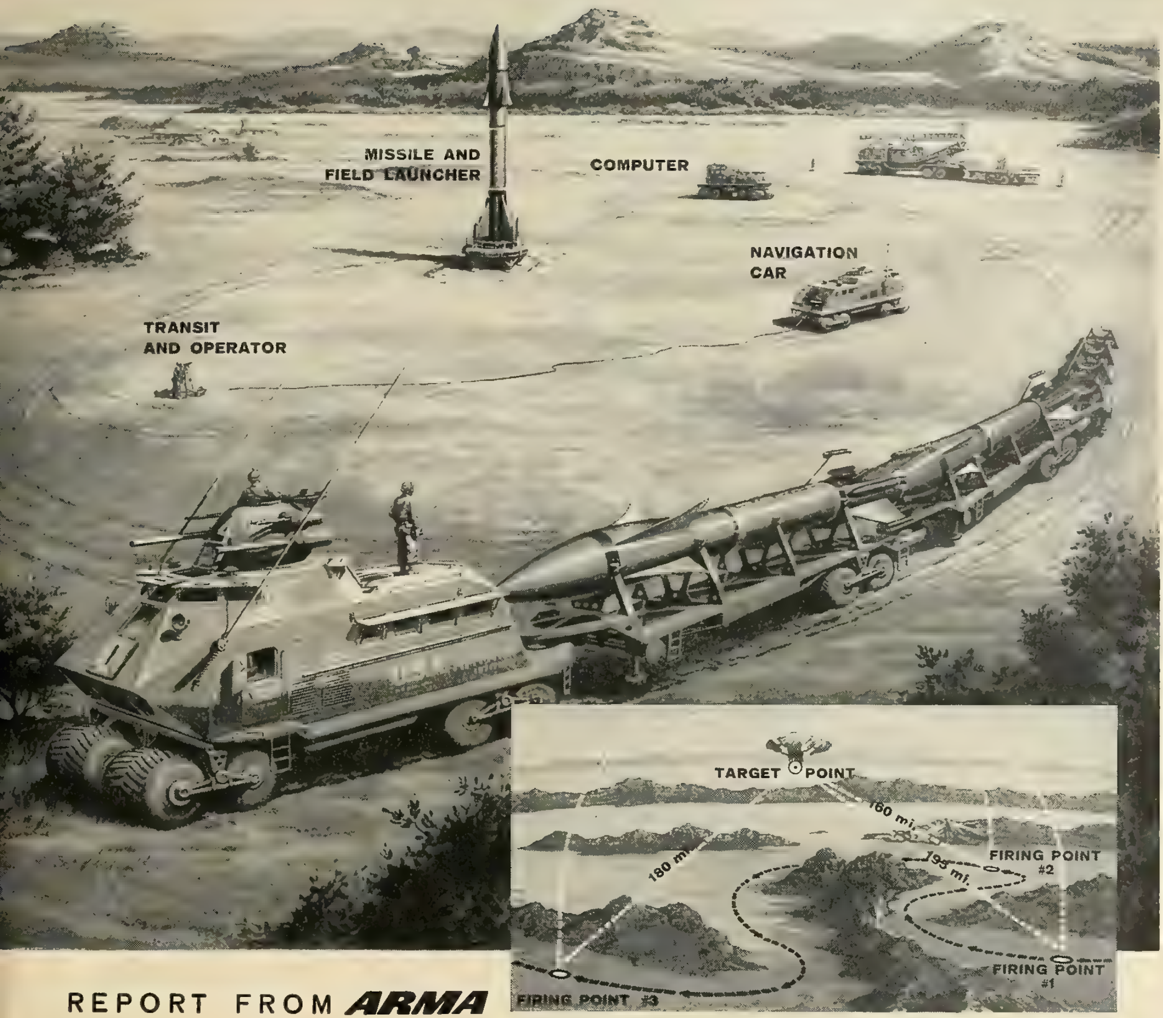
Richard B. Steinmetz, who has been with the Anaconda organization since 1929 and executive vice president since 1957, will succeed **William E. Sprackling** as president of Anaconda Wire & Cable Co.

Aaron Bloom, who has worked to translate the Latin of medicine into the equations of the engineer, has been appointed vice president in charge of engineering of the Sierra Engineering Co.

Richard C. Palmer will manage Stromberg-Carlson's office in Washington, D.C., as a new vice president of the division of General Dynamics Corp. He succeeds **Andrew H. Bergeson,** who has resigned to participate in the formation of a small business investment company which will provide capital and management services to companies in the electronics and avionics fields.

PALMER

Palmer, who previously held the posi-



REPORT FROM **ARMA**

The Missile Train—Mobile Sunday Punch

In the foreground above is the missile train—a hit-and-run Sunday punch for our modern Army. In event of war, the train could fire a missile with nuclear warhead, move rapidly miles away, then fire other missiles . . . without becoming a vulnerable stationary target itself. The missile train would be an ever-present threat to the enemy's tactical units over a wide area.

For such imaginative projects as the missile train, which combines maximum mobility with maximum firepower, ARMA has developed an equally imaginative universal navigation system. Not only can ARMA systems rapidly locate and aim all types of Army missiles, but they are applicable to all types of land, sea and air operations. To the Army, ARMA offers precise vehicular navigation systems for use in artillery and missile survey, combat vehicles, tanks, and helicopters as well as remote control types for mine detection and atomic blast survey. Precision navigation systems are ARMA's business from ships to ICBM's and—beyond.

ARMA, Garden City, N. Y., a division of American Bosch Arma Corp. . . . the future is our business.

Attention, Engineers: Write to E. C. Lester, Emp. Supv., about career openings in R&D programs.

AMERICAN BOSCH ARMA CORPORATION

DEPENDABILITY

another outstanding attribute of

DIMAZINE®

unsym-Dimethylhydrazine, UDMH

THE STORABLE FUEL

Performance data on DIMAZINE-powered rocket engines in military missiles and satellite launching vehicles shows DIMAZINE to be a highly reliable rocket fuel.

DIMAZINE provides fast, dependable hypergolic starts followed by smooth, stable combustion and easier shutdowns. Dependable instant readiness is assured for years by its outstanding stability during storage in missiles. It also has high performance, high thermal stability, low freezing point, low shock sensitivity, minimum susceptibility to contamination and high compatibility with almost all metals and appropriate sealing materials.

These manifold advantages combine to make DIMAZINE *the outstanding storable fuel*. We will be pleased to work with you in evaluating DIMAZINE and to supply detailed data on its properties and handling.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Westvaco Chlor-Alkali Division

General Sales Offices:
161 E. 42nd STREET, NEW YORK 17

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tion of vice president in charge of communications at Fairchild Engine and Airplane Corp., will also assist Stromberg-Carlson in Rochester in the coordination of company-wide government relations programs and military marketing.

Dr. Howard Percy Robertson, professor of mathematical physics at the California Institute of Technology and a member of President Eisenhower's Scientific Advisory Committee, has been elected to the board of directors of Northrop Corp. He is also chairman of the Defense Science Board of the Department of Defense.

John B. Moss has joined Vertol Aircraft Corp. as assistant to the president. **Robert Scheinfein** has been appointed vice president of General Measurements Co., Inc., Instruments Div., and **Melvin Kutchin** joins the New England Instrument Co. of Waltham, Mass. as sales manager.

Barnet R. Adelman, vice president of United Research Corp., subsidiary of Pacific Aircraft Corp., has been elected general manager of the corporation and a member of its board of directors.

Arthur R. Christie, a management consultant since August, 1958, for the Martin Company, has been named manager of its Washington office.

As part of its development in handling Research and Development organizations, George Fry & Associates has appointed **William W. Buchanan** to head its Washington, D.C., office.

when and where

NOVEMBER

Institute of Aeronautical Sciences, Annual National Midwestern Meeting, Wichita, Kan., Nov. 2-4.

The Combustion Institute, Western States Section, Fall Meeting: Equilibria and Performance of High Temperature Systems, Los Angeles, Nov. 2-5.

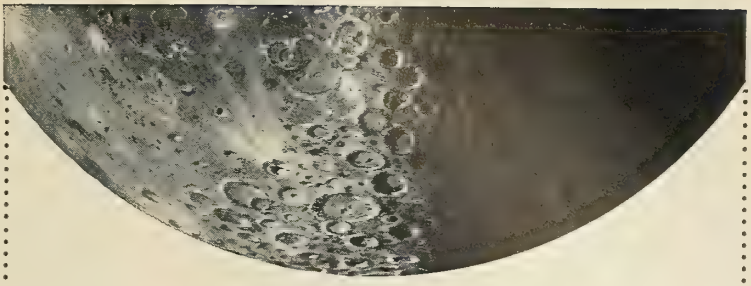
Society for Nondestructive Testing, 19th Annual Convention, Hotel Hamilton, Chicago, Nov. 2-6.

41st National Metal Exposition and Congress, International Amphitheatre, Chicago, Nov. 2-6.

Mid-America Electronics Conference, 11th Annual Meeting, Kansas City Municipal Auditorium and Hotel Muehlebach, Kansas City, Mo., Nov. 3-5.

American Management Association, Briefing Session on the Defense Market, (Same program to be held at Ambassador Hotel, Los Angeles, Dec. 7-9,) Hotel Statler-Hilton, New York City, Nov. 4-6.

Institute of Radio Engineers, Fourth IRE Instrumentation Conference, Biltmore Hotel, Atlanta, Nov. 9-11.



ROCKETDYNE
The Nation's Leader in Rocket Engines
Announces Limited Expansion in
RESEARCH

Some of the programs under study are:

The maximum specific impulse obtainable (compared to the classical infinite volume thrust chamber) for a rocket chamber which consists only of an injector and an exhaust nozzle.

Predicting the performance of a turbine operating with a gaseous working fluid which is still reacting and changing composition. The effect of boundary layer buildup, leading edge thickness, and radial flow on flow through supersonic turbine blades.

New methods of translating chemical energy into thrust, and how they will work in a rocket engine.

Types of fluid transport systems for rocket engines which offer simplicity, efficiency, and light weight. The fundamental parameters which govern the satisfactory operation of bearings and seals in corrosive propellant service.

Determine the separation point in an overexpended rocket nozzle as a function of nozzle divergence angle, and the applications of this phenomenon.

The dynamic interrelations of the various components of a rocket engine, and the control systems which best solve the problem of controlling a rocket engine.

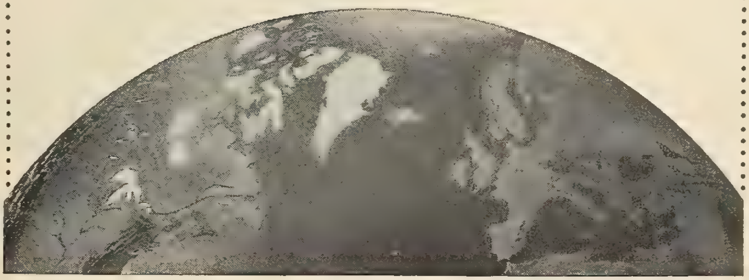
Participation in these combined theoretical-experimental activities presents a stimulating challenge and involves project-oriented responsibility.

Qualifications include:
Advanced degree in Engineering
Advanced degree in Chemistry, Physics
BS degree supplemented by appropriate experience

For specific consideration of your background in Applied Research Write to:

Mr. Stanley Greenfield, Chief
Engineering Sciences Research
Dept. 596 MR
6633 Canoga Avenue, Canoga Park, Calif.

ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION, INC.



Prototype MHD Power System Produces 1 KW

PHILADELPHIA—The successful generation of about 1 kilowatt of electrical power by means of a magnetohydrodynamic (MHD) power system has been accomplished experimentally here by **General Electric's** Aerosciences Laboratory. A continuous current flow was maintained for a period of 5 seconds.

In development for less than a year, the system will eventually find application in space vehicles by GE's Missile and Space Vehicle Dept.

The basic principles of MHD have been known for some time. Efficiency of such a device theoretically is higher than any heat-to-electrical energy power generation process now known, but application of theory to a complete working system has been a difficult problem, said GE.

The experimental unit directly converts the energy contained in a high-temperature (5000°F) air plasma into electrical energy. In comparison with a conventional generator, MHD employs the ionized gas as the conductor that moves through a magnetic field. Thus, it uses no moving parts.

Typical turbo-generators now in use convert thermal energy to useful electrical power at a rate of 0.35. General Electric expects future MHD generators to enjoy a conversion rate from 0.40-0.50.

The next step in MHD system development, said company spokesmen, is to reduce weight and increase reliability and efficiency. Also, there will be needed a refined power source and better high-temperature materials.

Soviets To Maintain Defense Spending in '60

WASHINGTON—The Soviet Union in 1960 will spend the same amount for defense and related fields as it is this year.

The expenditure—about $45 million—is approimately the same as anticipated U.S. defense-connected spending for the same period. But the outlay represents about 25% of the 1960 Russian gross national product, compared to 10% of America's GNP.

The comparisons were made by experts here last week after the Soviet Government in Moscow announced plans for a record overall budget in 1960 of $186 billion.

Because the total budget has risen, the $24 billion devoted to strictly military spending in 1960 represented 12.9% of the budget, a drop from 13.5% this year.

The space race will get a boost in funding—spending on scientific progress will be increased by 15.4% to a total of $8,150,000,000.

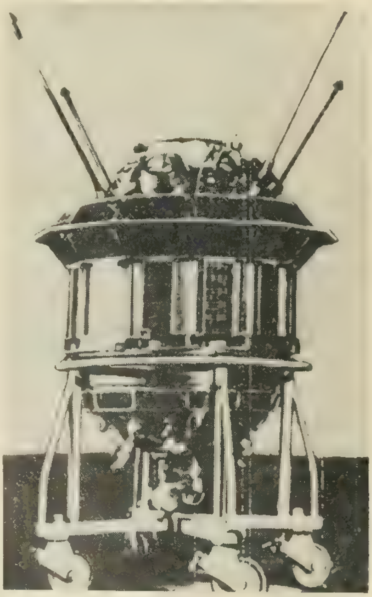
Other food for thought in the official budget forecast:

- Anticipated revenues for 1960 were put at more than $193 billion—a jump of $12 billion over this year. This would mean a surplus of nearly $7 billion at the end of the year.
- The government promised to abolish personal taxes "in the next few years."
- Total spending on consumer goods and food will rise by 13.6%.

Moreover, a Soviet report on economic development included these points:

- Industrial development in 1959 exceeded the targets for this year under the current seven-year plan; planned output of industrial goods would be exceeded by 4%, consumer goods by 10.5%.
- Gross industrial output in 1960 will rise 8.1%. Steel production will be 65 million tons, iron ore 105 million tons, and oil up by 15 million tons to 144 million tons.

Lunik III Model



MODEL OF Soviet automatic interplanetary station, in photo released by Tass. It's believed to be the type which photographed moon's far side (p. 13).

House Group Schedules Space Lag Investigation

WASHINGTON—The House Space Committee next January will conduct a month-long investigation to determine why the United States is behind Russia in space.

Chairman Overton Brooks (D-La.) announced the investigation would cover all phases of the nation's civilian and military space programs. He said that among the points that will be covered are:

- The future missions of the Air Force, Army, Navy and ARPA in space.
- The role planned for the Army Ballistic Missile Agency under NASA.
- The Administration's plans for the *Saturn* program and whether it should be accelerated.
- Whether more millions should be put into civilian or military space programs.

"The Congress and this country are not prepared . . . to sit back and twiddle their thumbs while we fall further behind in the race for space supremacy," Brooks said.

"I am convinced that this is a field in which we cannot play a subordinate role and still remain a first class nation. It is as simple and important as that."

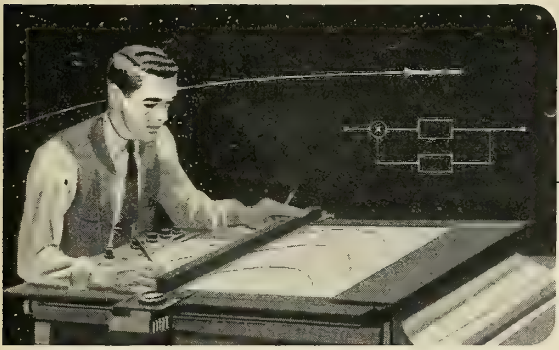
'Space Ferry' Concept Told by Hughes-Lockheed

LOS ANGELES—Concept of a "space ferry" capable of making a manned roundtrip into a 300-500 mile orbit with a 14,000-pound payload was revealed by **Hughes Aircraft Co.** and **Lockheed Aircraft Co.**

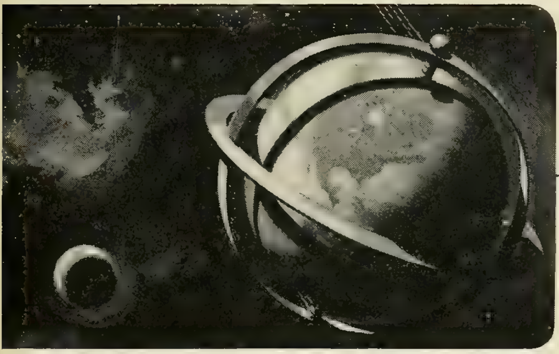
Most striking feature of the jointly-developed design is a 1000-square-foot folding "arrow wing" configuration somewhat similar to one being developed by NASA's Langley Research Center. The wing unfolds when the vehicle nears its target station—exposing the payload cylinder which has room for the pilot and three passengers.

The "space ferry" would require a three-stage booster with takeoff thrust of 1.3-to-1.5 million pounds. Gross takeoff weight would be about 1 million pounds; orbital injection weight would vary from 20,000 to 32,000 pounds. The design calls for a 7500-pound thrust throttleable engine for space maneuvering, retro impulse and landing assistance.

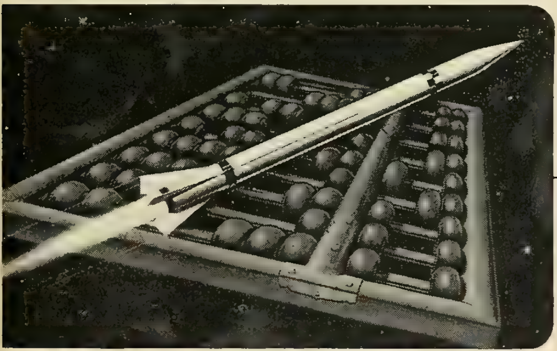
Pioneering Achievements in Electronics at JPL



GUIDANCE RESEARCH . . . by JPL has led and advanced the field of missile guidance. Among these achievements are the application of Wiener RMS methods to multiple-input, multiple-loop servos, and matching missile trajectory to missile control transfer function for optimum accuracy.

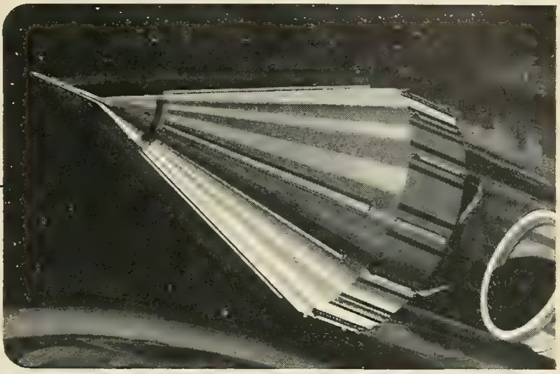


GUIDANCE SYSTEMS . . . both inertial and radio-command types employing new concepts of radar communication have been pioneered at JPL. This guidance system development activity is supported by basic research in all phases of electronics.

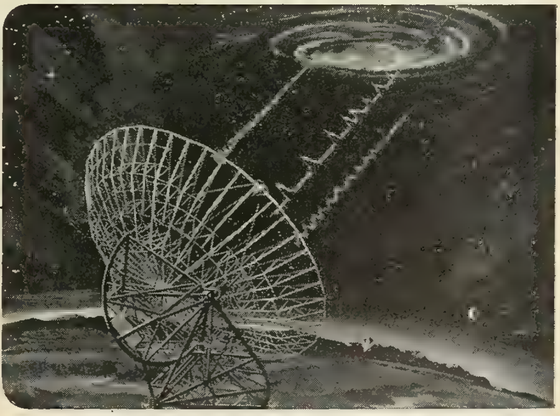


COMPUTERS . . . and the application of computing techniques to missile guidance systems have been pioneered by JPL. The Laboratory is now searching for new techniques that will further advance the state of the art in digital guidance components and computer systems.

DATA TRANSMISSION . . . brings news from space via the Explorer series. Explorer III used a tape recorder the size of a cigarette pack capable of transmitting two hours of information in 5 seconds. Electronic payload weight was approximately 11 lbs.



INSTRUMENTATION . . . of the moon probe provided measurement of radiation environment at distances far from the earth. Telemetered data revealed the existence of high intensity radiation. Miniaturization resulted in an instrument payload weighing only 10 lbs.



COMMUNICATIONS . . . pioneering in interplanetary communications resulted in this giant parabolic radio antenna, 85 feet in diameter, developed by the Laboratory which enables the tracking and reception of scientific data from great distances.

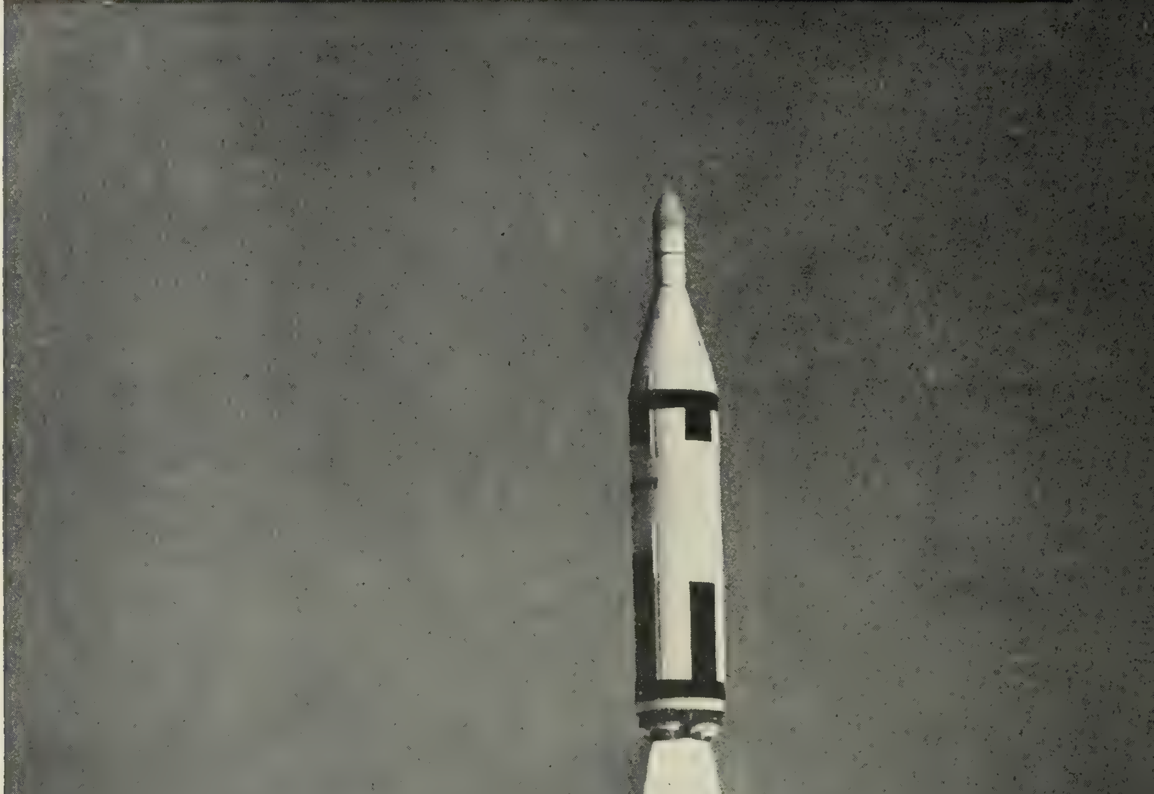
CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
A Research Facility operated for the National Aeronautics and Space Administration
PASADENA, CALIFORNIA

Employment opportunities for Engineers and Scientists interested in basic and applied research in these fields:

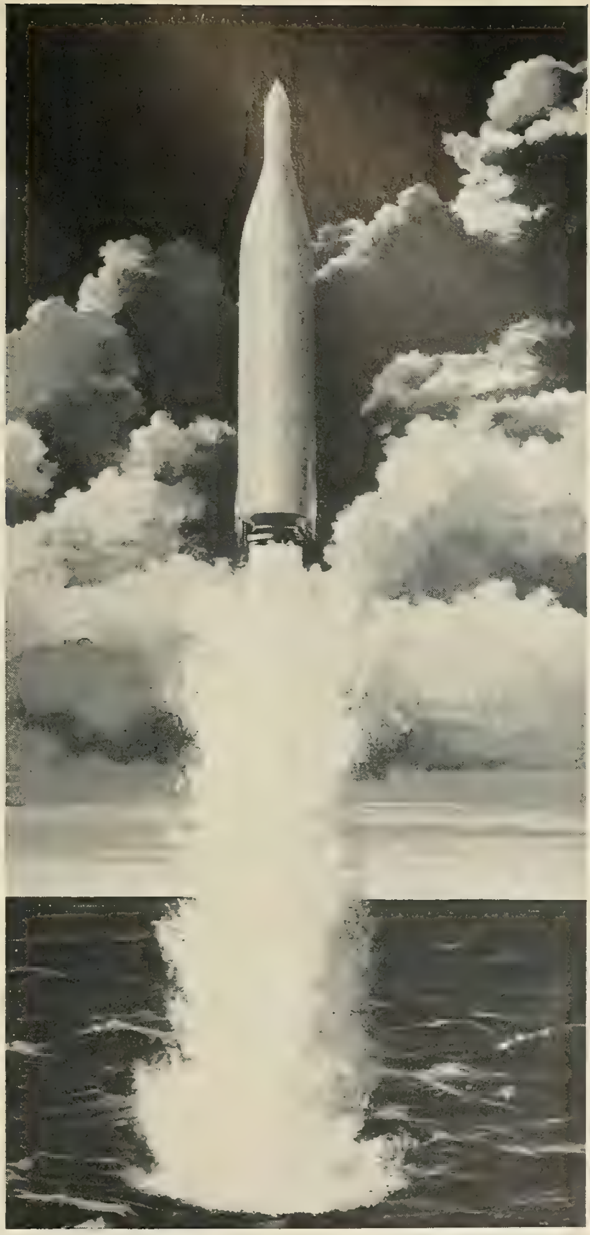
INFRA-RED, OPTICS, MICROWAVE, SERVOMECHANISMS, COMPUTERS, LIQUID AND SOLID PROPULSION, STRUCTURES, CHEMISTRY, INSTRUMENTATION, MATHEMATICS, AND SOLID STATE PHYSICS

Send professional resume, with full qualifications and experience, for our immediate consideration

The Log of the Navy's Polaris



1958 In January, just a year after the Navy had announced its
for a Fleet Ballistic Missile, the first Polaris test vehicle was
cessfully fired. Firings continued throughout 1958. By Septe
the test vehicles were close to the final configuration of the Po



1959 Operations Skycatch and Peashooter tested methods for ejecting the Polaris... Operations Pop-up and ishhook tested a submerged launcher. In August, a Polaris test ehicle was launched from the deck of the USS Observation Island.

1960 The Polaris is scheduled for active duty in late 1960. Each of the Navy's nuclear subs will carry 16. Lockheed is prime contractor and missile system manager of a team that includes Aerojet-General, General Electric, and Westinghouse.

LOCKHEED

MISSILES AND SPACE DIVISION

MISSILE RESEARCH & DEVELOPMENT • BALLISTIC MISSILE SYSTEMS MANAGEMENT
ROCKETRY • ULTRASONIC AERODYNAMICS • SPACE INVESTIGATIONS • NUCLEAR PHYSICS
ADVANCED ELECTRONICS • HIGH-SPEED AUTOMATIC DATA REDUCTION
RAMJET PROPULSION TESTING

more about the missile week

• **Huntsville**—Maj. Gen. August Schomburg, 51, Army deputy chief of ordnance, will succeed Maj. Gen. John B. Medaris as chief of the Army Ordnance Missile Command. Medaris retires Jan. 31. Schomburg, after presiding over the transfer of ABMA to NASA, will have a command comprised of the Army Rocket and Guided Missile Agency, which is responsible for missile maintenance and supply, and the White Sands Missile Test Range.

• **Washington**—Two U.S. satellites have plunged out of orbit, leaving five American satellites and Russia's *Sputnik III* still circling the earth. The casualties: *Discoverer VI,* launched last Aug. 19 by the Air Force from Vandenberg AFB; and *Explorer IV,* launched July 26, 1958, by the Army from Cape Canaveral.

• **Cape Canaveral**—A report that six missiles had been destroyed recently by spurious harmonics from commercial radio and TV broadcasts touching off destruct packages was branded "ridiculous" by Maj. Gen. Donald N. Yates, commander of the missile test center.

• **New York**—U.S. Missile and space programs are being pinched by the steel strike. Shortages in special types of steel, said Defense Secretary McElroy, are causing serious delays in missile fabrication. Space Chief Dr. T. Keith Glennan said work also has been set back on the three-stage *Vega* rocket, with which the U.S. hopes to match some of Russia's early space work.

• **New York**—Big increases in earnings for the first nine months of the year were reported by **Thiokol Chemical** and **Aerojet-General Corp.** Thiokol's net of $4 million on sales of $128 million was up 134% over the same period last year. On record sales of $258 million, **A-G** earned $6 million—up 63% from 1958.

• **New York**—**Republic Aviation** reported earnings of $2.6 million on sales of $152 million for the first nine months of the year compared to a $3.9 million net on sales of $133 million for the like period last year. On Sept. 20, the company had a $500 million backlog.

• **Los Angeles**—**Northrop Corp.,** which acquired **Page Communications Engineers** this year, said consolidated net income for the FY ended July 31 was $7.3 million on sales of $263 million compared to a net of $7.2 million on sales of $274 million for the preceding year. Earnings per share were $4.01.

• **Arnold AFS, Tenn.**—The Air Force dedicated a gas dynamics laboratory at the Engineering Development Center to rocket pioneer Dr. Theodore Von Karman.

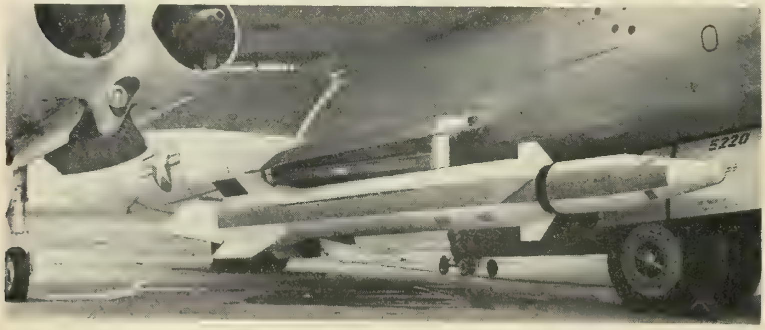
• **Washington**—NASA expects to launch NERV (nuclear emulsion recovery vehicle) from the PMR next year using the four-stage D-8 research rocket. Designed to obtain more complete measurement of the Van Allen radiation belts, NERV is being developed by **General Electric** under a $536,000 contract.

• **Fort Sill, Okla.**—Three more *Lacrosse* battalions will be activated by the Army early next year. It will put **Martin** *Lacrosses* in seven operational units.

Mergers & Expansions

In a diversification move, **Acoustica Associates** is negotiating for the purchase of **Ender Monarch Corp.,** Garfield, N.J., manufacturer of fluorescent light fixtures . . . **General Mills** has acquired the **Magnaflux Corp.,** Chicago, 30-year specialist in non-destructive testing of materials . . . Another Chicago firm, **Langmar Corp.,** has been purchased by **Basic Products Corp.** for its **Hevi-Duty Electric Co.** division at Milwaukee. Langmar makes vacuum pumps . . . A producer of magnetic components for missiles, **Luther Mfg. Co.,** North Hollywood, Calif., has been purchased by **Giannini Controls Corp.** . . . **Republic Electronics,** Farmingdale, L.I., is creating a new bio-dynamics division to specialize in aero-space instrumentation . . . A missile environmental testing facility will be built at Orlando by **Associated Testing Laboratories Inc.,** Caldwell, N.J. . . . and **Aeronca Mfg. Corp.** is regrouping all of its West Coast activities into a newly organized **Aerocal Division** at Torrance, Calif. The division has a $500,000 subcontract from **Boeing** for *Bomarc* structures.

First Released Photo of Bold Orion



MARTIN BUILT 199B ***ALBM*** **shown attached to B-47, manned by a Martin Company crew, which took off near Baltimore Oct. 13 and fired the two-stage Air Force R&D bird into the vicinity of paddlewheel satellite** ***Explorer VI*** **over Atlantic Missile Range near Cape Canaveral.**

Hawk Nerve Center Put in Aluminum Shelter

ANDOVER, MASS.—A new lightweight, aluminum shelter housing the battery control system of the *Hawk* missile system was displayed at the recent Open House held by the **Raytheon Company.**

Manufactured by **Craig Systems Inc.,** the shelter is easily transportable and is constructed of high-strength aluminum panels bonded together with epoxy resins.

The unit is insulated and contains a combination air conditioner and heater which maintains optimum operating temperatures in all types of weather conditions.

B.F.Goodrich

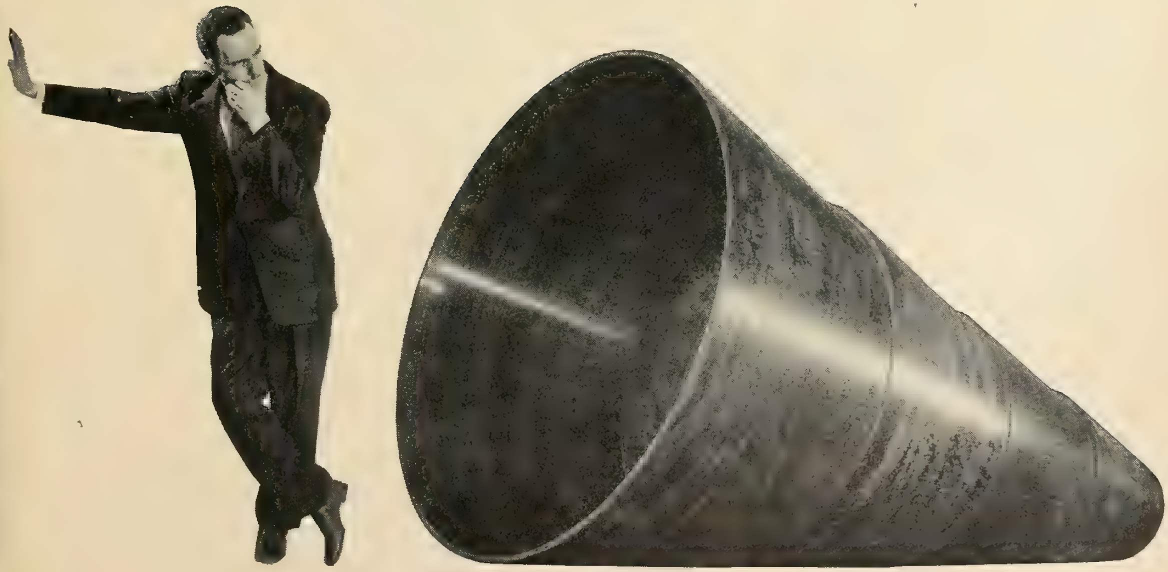
WHAT IS IT? Probably the biggest homogeneous void-free laminate ever built . . . a B. F. Goodrich ablation shield for an experimental re-entry vehicle designed and built by General Electric to be test flown on an Air Force Atlas ICBM.

Fabricated by a special B. F. Goodrich winding technique, the shield contains about five miles of high-temperature resin tape. This fabricating technique, which is also being used for many other specialized B. F. Goodrich products of various types and sizes, completely eliminates precision matched metal molds, cuts tooling costs by hundreds of thousands of dollars, and saves plenty of lead time. Autoclave curing replaces massive high pressure presses.

Throughout the construction of this re-entry vehicle shield, B. F. Goodrich maintains constant quality control of resin content and residual volatiles. Modern radiological facilities are used for final checking.

The fabrication and curing of such huge void-free parts illustrates the advances made by B. F. Goodrich in producing high-temperature, reinforced plastic products. So if you're up in the air and want down-to-earth answers on plastic laminate constructions, contact *B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MR-119, Akron, Ohio.*

B.F.Goodrich *aviation products*



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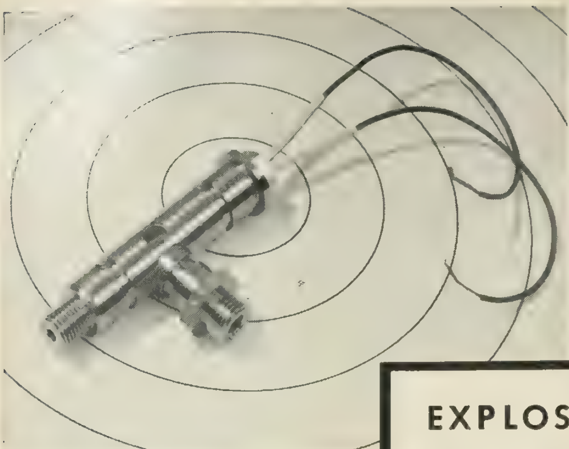
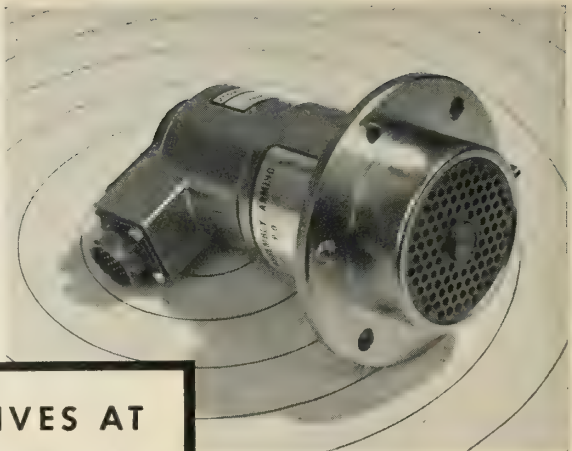
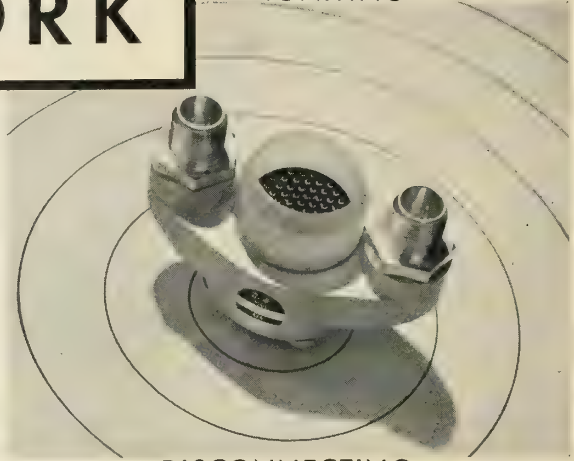
EXPLOSIVES AT WORK


VALVING


IGNITING

DESTRUCTING


DISCONNECTING

missile hardware

When it comes to the problems of putting propellants and explosives to work on the actuating jobs in and around missiles, Beckman & Whitley offers a background gained in ten years of pioneering. Examples shown are just a few selections of solutions to typical problems.

They include a zero-leakage re-usable non-contaminating valve, a lanyard-armed destruct package, a rocket-engine starter for operation at altitude, and a standard electrical connector adapted for propellant-actuated disconnecting. Our case-history files are full of other examples, and if these don't happen to touch on your present problems, some of the others undoubtedly will.

This engineering capability, these production facilities, and our tradition of performance and reliability are at your disposal. Applications-engineering assistance is available in the solution of your problems.

Beckman & Whitley INC.

SAN CARLOS 16, CALIFORNIA

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MACHINING

(*continued from page 32*)

• **Beryllium**—This program presented a different picture. **American Beryllium and Nuclear Metals Inc.** participated in an initial phase similar to that in the steel effort.

Conservation was a factor here; development extrusion billets of beryllium run well over $100 a pound. One extruder backed up each billet with a less expensive alloy so that none of the valuable metal was lost as billet butts, the residue at the end of an extrusion run.

The extrusion processes were similar to those in the steel program, but the participants had to use heavier tooling because beryllium characteristically resists deformation at extrusion temperatures.

By far the most important consideration was the choice and technique of billet and die lubrication. Glass proved to be the best material but a host of application problems accompanied the early extrusions. It is still a headache. The reason for this is that beryllium is highly abrasive; should the lubrication fail for any reason, the die is quickly washed out.

The possibility of bare beryllium extrusion was proven. Future process improvements are expected to make popular structural shapes of the metal available within two years.

SOLID FUELS

(*continued from page 25*)

weight 19, can do the same job. Some way must be found to use fluorinated oxidizers.

The third ingredient of a composite propellant is the metal additive—now usually aluminum, weight 27. There are three light elements—lithium, beryllium and boron—that might be able to do the same job.

Chemists also are investigating the mechanism of combustion and stability of the product gases at the temperatures produced in rocket flames. N_2, CO and HF are quite stable, even above 5000°F. But H_2O and CO_2 are considerably dissociated. Energy that might have added to the impulse is used in dissociation, another reason for introducing more fluorine into solid propellants.

Even when higher-impulse propellants are developed, one problem may stand in the way of their use. Higher impulse often depends on higher flame temperatures. Unless new materials are developed, we may not be able to make use of the improved propellants.

new missile products

Radiation Furnace Operates at 4200°F

A new refractory-free, high-temperature vacuum furnace for critical heat treating has been announced by **General Electric's** Industrial Heating Department.

The new furnace operates at temperatures up to 4200°F and is designed for use in laboratories or for production work where vacuum operation is required. Parts or material up to 10 inches in diameter by 10 inches in height, weighing up to 50 pounds, can be processed in the furnace. Heating space is 15 inches in diameter by 16 inches high to provide temperature uniformity in the load area.

The console units are factory-assembled, and include the radiation shield furnace, its vacuum system, furnace transformer, General Electric's Reactrol control system, and full instrumentation. The entire system is prewired and prepiped so that only power, water and vacuum system connections are needed when installed.

Double-wall furnace casing is entirely of stainless steel with radiation shields surrounding the load to provide thermal insulation. Radiation shields provide thermal insulation by reflecting heat back into the load. Inner shields closest to the load and which operate at highest temperatures are tungsten. Those furthest from the work which operate at lower temperatures are molybdenum. The last shield, which supports the others, is stainless steel.

Shields are constructed in small overlapping segments providing reduced distortion and fatigue due to repeated changes in temperature, according to company engineers.

The furnace cover is raised and lowered by screw-type mechanism, and top radiation shields move up and swing out for ease of loading and full access to heating chamber.

Heating elements for the new furnace are 1/8-inch tungsten rods, connected in parallel, and operate at less than 10 volts. Rods can be replaced individually. The electrical rating of furnace is 50 kilowatts. Power is supplied to the tungsten elements through water-cooled copper flanges.

Vacuum system operates on 6-inch oil diffusion pump rated 900 cfm at 0.01 micron, 1500 cfm, at 0.1 micron. Inert or reducing atmospheres can be used at partial pressure.

Typical applications include heat treating, brazing, sintering, solution heat treating and degassing of metals such as stainless steels, super alloys, tungsten, tantalum, molybdenum, columbium (niobium), titanium, vanadium, zirconium, hafnium and ceramics.

Circle No. 237 on Subscriber Service Card

Color Film Tracks High-Speed Missiles

A high-speed color motion picture film—fast enough to track a speeding missile and sharp enough to pinpoint almost indistinguishable changes in flame patterns—has been introduced by **Eastman Kodak Company.**

Eastman Color Reversal Film, Daylight Type, SO-260 has a normal exposure index of 160. It can capture motion in color under lighting conditions that challenge the highest-speed, black-and-white cine films. In use for missile data recording, the film has been exposed at indexes up to 500. Almost as sensitive is the new film's tungsten-balanced (artificial light) companion, Eastman Color Reversal Film, Type B, SO-270, which has a normal exposure index of 125.

The new film's speed combined with adequate sharpness, moderate grain pattern and good color reproduction make them suitable for recording all types of scientific and technical data under unfavorable lighting conditions. Tests indicate that they will be particularly useful in the missile and aircraft industries in missile tracking, flame and aerodynamic studies—especially when data is required concerning color changes. Another probable major application will be in filmed progress reports and in facilities presentations.

Because of the new films' increased sensitivity to light, the colored nose cone of a missile is said to be easily distinguished against the sky in motion picture footage. In addition, the films' speed allows photo engineers to take advantage of the superior resolving power of longer focal length lenses (which require smaller lens openings and consequently more light.)

As an example of what the higher speed of the new Daylight-balanced SO-260 film means in terms of exposure under low light levels: at a shutter speed of 1/50 second at 24 frames per second sound speed with a lens aperture of f/1.4, the new film may be exposed at the normal 160 rating with only 14 foot-candles of incident illumination.

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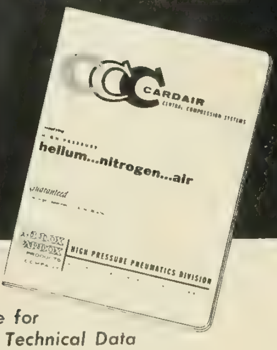
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propulsion engineering . . .

By JAY HOLMES

Are we throwing away $800,000 . . .
in cancelling the *Pershing* titanium-case program? **Pratt & Whitney,** a sub for **Thiokol** and **Martin-Orlando,** spent this much money in the last year developing the case for the Army's solid-fuel battlefield missile.

Money alone was the issue . . .
in the decision to scrap the program. Army spokesmen say there were no technical problems involved. The switch to steel saved many dollars; the exact sum is classified. One source says it cut 4% from the unit cost of the missile.

The decision cut 50 miles . . .
from *Pershing's* range, which approaches 700 miles. This is far beyond the Army's theoretical limit of 200 miles. Army money has been getting scarcer and scarcer. And so, planners reasoned: Why spend it on extending the range of *Pershing* far beyond the limit?

This makes good sense . . .
from the Army point of view. But how about the national viewpoint? Must we throw away a valuable technology because one of the three services has no need of it? Pratt & Whitney is far ahead of the field in fabricating titanium, industry sources say.

P&W makes one-piece weldless cylinders . . .
by flow-turning titanium. Others making experimental titanium cases weld them with a longitudinal seam. Titanium makers fear that welding technique is not advanced enough to do this with the new metal, although it has been successful with steel. They are afraid weak spots may develop in seam welds.

Circular weld seams are not so critical . . .
The geometry of a burning rocket motor puts far less strain on a circular weld than on one extending the length of the case. Thus, there may be some strength to spare in the seam that holds the hemispherical head to the case.

Much study is still necessary . . .
before anyone can make a final evaluation of titanium for missile cases. Much research is in progress. We are learning about tensile strengths, notch sensitivity, elasticity, heat treating and how to weld the metal. Knowledge of this sort is increasing every day.

But the ultimate test . . .
is in making a case. Using the knowledge available, will it do the job? This is what P&W was doing. All of the preliminary work had been completed. Small-scale cases had been fabricated successfully and P&W had just begun to make full-scale cases. Then the program was cut off.

In final analysis cost may still be prohibitive . . .
Mill titanium costs $7 a pound, compared with $1.50 for vacuum-melted steel. We certainly must think twice before spending this much extra, particularly for large cases. But it seems silly to scrap the program without learning all the facts.

We have two other missile programs . . .
that might make good use of P&W results, for comparison with their own experience. The **Boeing** *Minuteman* and the **Lockheed** *Polaris* have solid-fueled motors that face the same problems as the *Pershing*. Their ranges are longer but the principles are the same.

There is one roadblock, of course . . .
Minuteman is an Air Force weapon and *Polaris* belongs to the Navy. There is the question whether either would be willing to take over an Army program. Stated more simply, the question is whether the services are truly unified.

letters

Space Vehicle Power

To the Editor:

Your article on "The Search for Space Vehicle Power" by C. Paul Means (M/R, July 27) was of great interest, especially your discussion of rotating electrical machinery.

S. M. Weinberger
Chief Engineer
Advanced Development
Rotating Machinery
The Louis Allis Co.
Milwaukee

Auburn's Role Clarified

To the Editor:

We were extremely happy to read the articles by Frank G. McGuire regarding ignition in M/R Oct. 5 and Oct. 12.

In the Oct. 12 story, we would like to make the following corrections:

1) We do not make ignition systems for sale. We do make jet plugs, shunter surface igniters, torch igniters, aircraft connectors, etc.

2) On page 24 you showed an **Auburn**-manufactured torch igniter, picture taken at **Aerojet-General**, with caption reading: "Torch igniter by Aerojet-General uses gasoline . . ." It should have read: "Torch igniter manufactured by Auburn Spark Plug Co., shown in photo by Aerojet-General, uses gasoline, air and a spark plug. Units of this type, etc."

A. J. Battey
Chief Engineer
Auburn Spark Plug Co., Inc.
Auburn, N.Y.

Right Data, Wrong Photo

To the Editors:

The caption and cover data in the Oct. 12 issue of M/R are incorrect as they apply to the cover photograph. The piece of equipment shown is incorrectly described as a plasmatron; it is a drilling machine which a technician is using to drill a hole in the nozzle of the XLR99 (*X-15*) engine. The circle of light is a fluorescent lamp which provides illumination for the drilling operation.

Tom Johnston
Brown & Butcher, Inc.
Advertising
(For Thiokol Chemical Corp.)
630 Fifth Avenue
New York 20, N.Y.

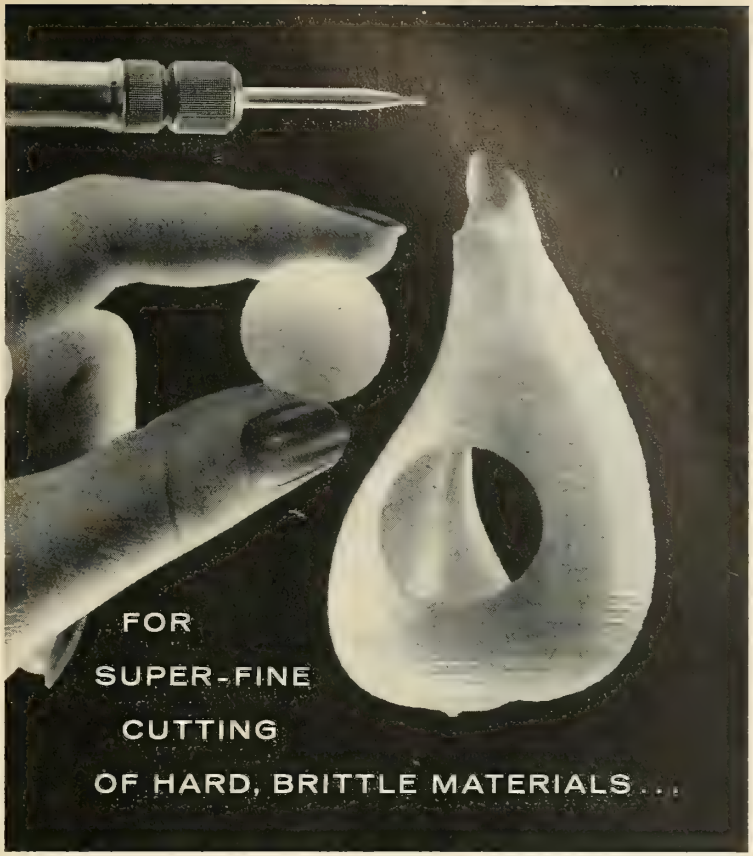
M/R mismatched the caption and cover data with another photo.—Ed.

Written on LA Freeway?

To the Editor:

This world does not have an unlimited amount of space for an unlimited amount of people. The laws of nature have a statute of limitations; there are those who choose to ignore them, for which we all have to pay.

William R. Sullivan
1116 S. Flower
Los Angeles 15, Calif.



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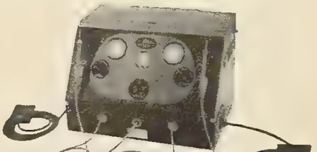

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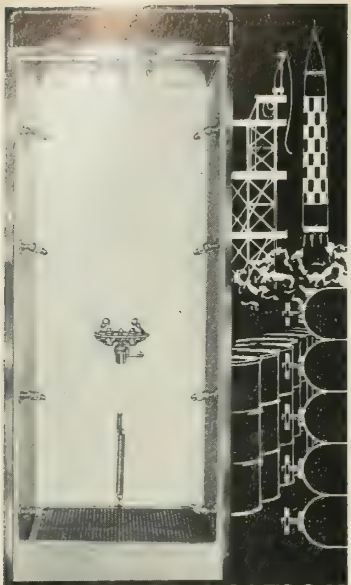

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west coast industry . . .

By FRANK G. McGUIRE

The Small Business Administration tells this column that business in Southern California is in "pretty good shape." The number of loans being sought by small business is on the upswing, but SBA says this is a sign of additional working capital and expansion funds being appled for. About 55% of the loan applications are approved; most rejections are blamed on lack of adequate collateral. The two criteria necessary for obtaining an SBA loan are adequate collateral and a good earning record. ("This is taxpayers' money we're using, and we have to have both of these things before approving a loan.")

SBA prefers to work with private banks in helping small business, and will go it alone only if the local banks have turned down an application. Such a refusal by private lending institutions does not necessarily reflect adversely on the small firm's credit record; it might mean merely that the company needs the money for a longer period than the bank can accept. Thus, the small firm goes to SBA, which can make much longer-term loans than banks.

The Gabriel Company will integrate . . .

two of its divisions, **Talco Engineering Co.** and **Rocket Power, Inc.**, both in Mesa, Ariz. President of the two divisions will be Charles E. Bartley, formerly with **JPL** and founder of **Grand Central Rocket Company.** Rocket Power, Inc. is a producer of solid propellants and rocket systems, and has a new propellant facility nearing completion at its Mesa site. Talco Engineering manufactures cartridge actuated devices and pilot-escape systems.

Industrial Annual Reports . . .

have replaced the 16th-Century sonnets written by businessmen about their mistress' feet, says a report out of UCLA. "The annual report is the natural child of bureaucracy—whatever its uses, whether it is read or not, we can't do without it," says a university librarian. Among the suggestions given to report-writers are: digest details properly—and reject most of them; beware of deadliness; eschew technical language; determine reasons for the report, and at what group it is aimed; don't overuse statistics; and don't air internal administrative troubles and reorganization jangles in a public report . . . "if necessary, write two reports."

Convair Astronautics is trying to convince . . .

the Defense Department that advanced modifications of *Atlas* could carry greater payloads. The missile is under continual modification now, but **Convair** is apparently looking for a big step. The division has also expressed an interest in solid propellants, but diluted this with: ". . . but then, we're interested in all propellants."

Dozens of *Polaris* nozzle modifications . . .

have occurred since the program began. Original nozzles which used molybdenum extensively were modified when hotter propellants came along and other materials with greater high-temperature strength were substituted. One model utilizes half a dozen different materials: 4130, graphite, pyrotex, molybdenum, and a tantalum/tungsten throat. Even the shape of the nozzle has changed. The characteristic bell-bottom shape of the nozzle shown on models has given way to a straighter contour because the jetavators kept jamming on the "ball" of the nozzle during high-temperature phases. Some of the lastest models use tungsten to a greater extent than ever.

Visitors to Aerojet-General/Sacramento . . .

rocket engine test facility are often awed by the towering but strangely shaped structures used for casting and curing of solid-propellant rocket motors. Tour guides and part-time comedians who point out that "if we lose our missile contracts, we can always use it for a cathedral," had a jolt recently from a visitor who beat them to the punch (he had heard the story) by suggesting that the towers be used for "further hypergothic fuel development."

contracts

NASA

$536,000—General Electric Corp., Missile and Space Vehicle Dept., Philadelphia, for development of a recoverable device for measuring radiation in space.

$111,875—Jones-Mahoney Corp., Tampa, Fla., for services and materials for the construction of a radio tracking station.

$68,000—Massachusetts Institute of Technology, for design, construction, testing and delivery of a high energy gammaray detector.

$37,761—Minneapolis Honeywell Regulator Co., Brown Instrument Div., Cleveland, Ohio, for 24-channel galvanometer type oscillograph for the Lewis Research Center.

NAVY

$1,291,000—Sperry Gyroscope Co. Div., Sperry Rand Corp., L.I., N.Y., for field engineering services in connection with the maintenance, repair, installation and check-out of guided missile fire control systems, *Terrier* and *Talos* components manufactured by the contractor.

$517,518—D. S. Kennedy & Co., Cohasset, Mass., for engineering, design, development, fabrication, assembly and installation of large antenna for satellite tracking and propagation research.

$356,004—Sylvania Electric Products, Inc., Towanda, Pa., for materials, services and personnel to investigate and develop processes for producing improved quality molybdenum alloy sheets.

$279,020—Daystrom, Inc., Systems Div., for services and materials to design, manufacture and install one multi-channel quantitative spectrum and analyzer.

$47,481—Kaiser Alum. and Chem. Sales, Inc., N.Y., for synchro and resolver transmission cable for guided missile system.

$43,000—Massachusetts Institute of Technology, for conducting an investigation of chromium-base alloys for use at elevated temperatures.

$41,854—New York University, for conducting an investigation to develop improved titanium organic compounds.

$35,285—American Institute of Research, Inc., Pittsburgh, for research to insure maximum effectiveness of a weapon system.

AIR FORCE

$7,776,637—Hughes Aircraft Co., Culver City, Calif., for repair and modification of fire control and weapons control systems components.

$675,680—Amperex Electronics Co. Div. of North American Philips Co., Inc., Hicksville, N.Y., for electron tubes.

$550,000—Century Electronics & Instrument, Inc., Tulsa, to develop calibration carts for the *Minuteman* ICBM test program. Subcontract from **Boeing Airplane Co.**

$476,000—Radiation, Inc., Melbourne, Fla., for developing a tape format converter for the *Minuteman* ICBM test program. Subcontract from **Boeing Airplane Co.**

$287,820—Radio Corp. of America, Harrison, N.J., for electron tubes.

$80,458—University of Chicago, for continuation of research on nuclear emulsion studies of the properties of hyperfragments.

$63,497—Sylvania Electric Products, Inc., N.Y., for electron tubes.

$55,900—Raytheon Mfg. Co., Newton, Mass., for electron tubes.

$53,120—Florida State University, for research on "Ionization Processes in Nitrogenring Compounds."

$45,788—Cornell University, for research on "Analytical Applications of Flame Spectroscopy."

$41,828—The University of Kansas, for research on "Determination of Organic Functional Groups by Photometric Titration."

$32,640—General Electric Co., Owensboro, Ky., for electron tubes.

$30,208—Rensselaer Polytechnic Institute, Troy, N.Y., for continuation of "Analysis of Dynamic Effects of Added Mass and Initial Stresses."

$25,000—University of California, for continuation of research on "Development of Arc Heated Low Density Wind Tunnel."

ARMY

Aerojet-General Corp., Azusa, Calif., has received a contract to conduct basic research studies of electrically exploded wires and films. Amount not disclosed.

$188,402,905—Western Electric Co., N.Y., for research and development of the *Nike-Zeus* guided missile system.

$2,885,000—The Martin Co., Orlando, for test and ground equipment for the *Lacrosse* missile.

$2,067,138—General Electric Co., Phoenix, for digital computation facility operation at ABMA, Redstone Arsenal.

$2,003,400—Hughes Aircraft, Fullerton, Calif., for tracking systems associated with classified equipment.

$998,800—The Martin Co., Orlando, for research and development of *Lacrosse* missile.

$700,000—Vertol Aircraft Corp., Morton, Pa., for the manufacture of various components for the *Hawk* surface-to-air missile. (Included in this is an earlier contract for acquisition antennas for the *Hawk* missile.) Subcontract from **Raytheon, Inc.**

$500,000—The Martin Co., Denver, for engineering services in connection with the *Saturn* program.

$326,958—Douglas Aircraft Co., Los Angeles, for *Nike-Hercules* launching area items.

$304,000—North American Aviation, Rocketdyne Div., for a classified project.

$275,000—North American Aviation, Inc., Canoga Park, Calif., for rocket engines.

$240,000—Hayes Aircraft Corp., Birmingham, Ala., for engineering and design services, ground support equipment for *Saturn* missile.

$239,699 — Bowen-McLaughlin-York, Inc., York, Pa., for increased vehicle engineering agency services for the T88 series, medium recovery vehicle, modification of three vehicles.

$154,638—Brown Engineering Co. Inc., Huntsville, Ala., for engineering and machine shop services.

$130,357—Aerojet-General Corp., for warhead.

$126,990—Central Electronics Mfgrs., Div. of Nuclear Corp. of America, Denville, N.J., for electron tubes.

$125,000—Maurice H. Connel & Associates, Inc., Miami, Fla., for architect-engineer services in connection with launch facility.

$100,055—The Martin Co., Orlando, for facilities for production of *Lacrosse* and *Pershing* weapon systems.

$92,682—Aerojet-General Corp., for activation and operation of launching equipment.

$84,979—Plasmadyne Corp., Santa Ana Calif., for experimental study of propulsion system.

$61,611—Douglas Aircraft Co., Inc., for *Nike* replenishment spare parts.

$56,160—Linde Co., Cleveland, for one item of liquid oxygen.

$47,722—Hayes Aircraft Corp., for engineering, design services and specialized services for manufacture of special tooling and fixtures of missile components.

$45,082—The General Electric Co., Cincinnati, for cesium ion rocket performance evaluation.

$39,924—Redel, Inc., Anaheim, Calif., for mechanistic studies of igniters.

MISCELLANEOUS

Itek Corp., Waltham, Mass., has received more than $12,000,000 in contracts, one is for the development and manufacture of special equipment for the space program.

$1,000,000—Hunter-Bristol Div., Thiokol Chemical Corp., for deisgn, development and production of a rocket-catapult ejection device for the B-58 supersonic bomber escape capsule. (Subcontract from **Stanley Aviation Corp.**)

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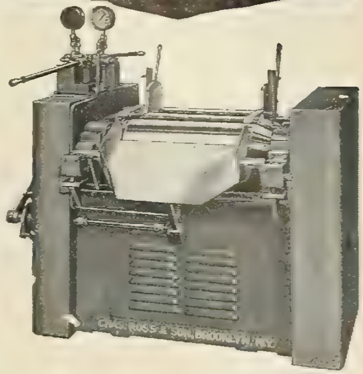

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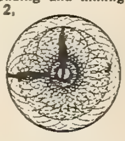

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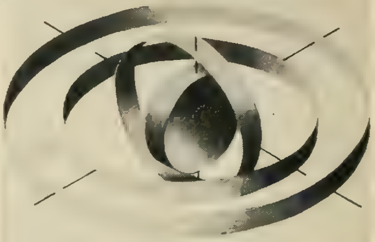

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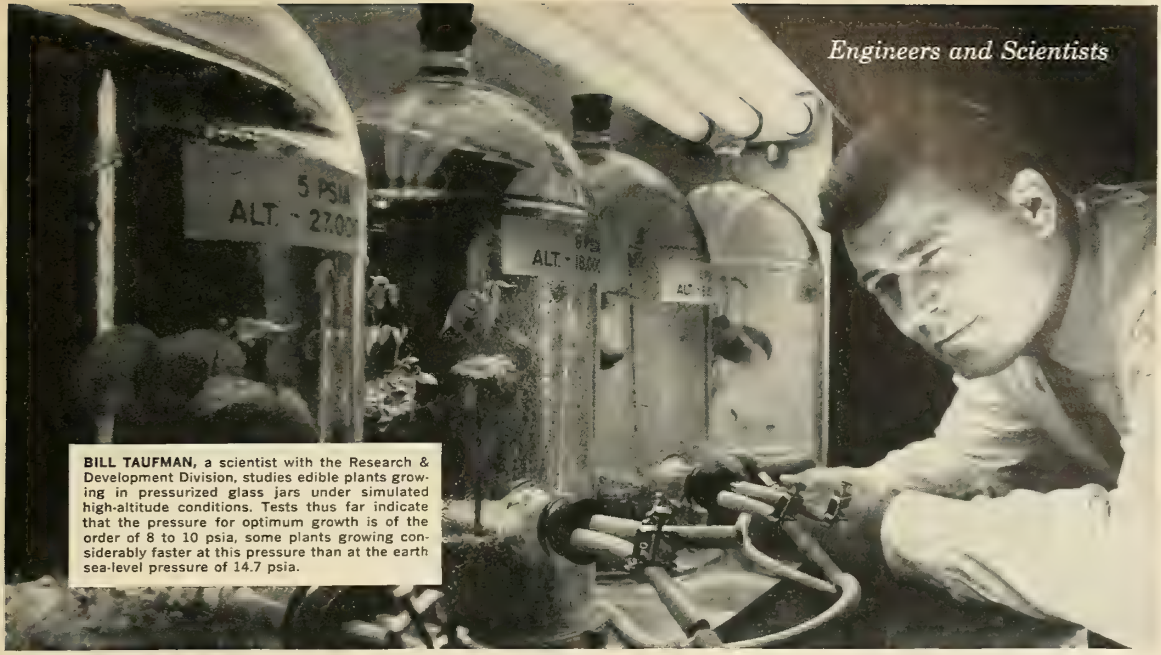

Engineers and Scientists

BILL TAUFMAN, a scientist with the Research & Development Division, studies edible plants growing in pressurized glass jars under simulated high-altitude conditions. Tests thus far indicate that the pressure for optimum growth is of the order of 8 to 10 psia, some plants growing considerably faster at this pressure than at the earth sea-level pressure of 14.7 psia.

HOTHOUSE ON THE MOON

Studies in low-pressure plant growth for lunar application... just one of the unique programs for engineers and scientists at REPUBLIC AVIATION

An example of the scope of Republic's investigations into every ramification of space exploration is a study to determine the lowest pressure level which will permit normal plant growth. The project is part of an Air Force program to judge the feasibility of a moon base. Another aspect of the study seeks to find the effect of zero gravity on plant growth. Although zero gravity cannot be created on the earth, the potential problems were indicated when plants subjected to negative g, or up-side-down growth, showed only one-half the development of normally grown plants.

Every facet of flight technology, from advanced aircraft design and space vehicle propulsion systems to computer-based trajectory studies for planetary reconnaissance probes, is being explored in Republic's Research and Development program. Distinguished advances have already been made in space guidance concepts, in plasma and nuclear propulsion systems, in radiation physics, in new materials and processing techniques, and in prototype development of hardware (as an example: hydraulic systems that operate reliably up to 1500F.)

These programs will be intensified with the completion – early next year – of Republic's new $14 million Research and Development Center. As the date draws near, staff expansion for these modern facilities is creating in-at-the-beginning career opportunities for senior engineers and scientists capable of sophisticated thinking in theoretical and experimental research. Republic invites qualified individuals to discuss how they can make material contributions to advancing the state of the art.

Opportunities In All Areas of Flight Technology

Electronics

- Inertial Guidance & Navigation
- Digital Computer Development
- Systems Engineering
- Information Theory
- Telemetry-SSB Technique
- Doppler Radar • Countermeasures
- Radome & Antenna Design
- Microwave Circuitry & Components
- Receiver & Transmitter Design
- Airborne Navigational Systems
- Jamming & Anti-Jamming
- Miniaturization — Transistorization
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Thermo, Aerodynamics

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- Hyper-Velocity Studies
- Astronautics Precision Trajectories
- Airplane/Missile Performance
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- Stability and Controls
- Flutter & Vibration
- Vehicle Dynamics & System Designs
- High Altitude Atmosphere Physics
- Re-entry Heat Transfer
- Hydromagnetics

Plasma Propulsion

- Plasma Physics
- Gaseous Electronics
- Hypersonics and Shock Phenomena
- Hydromagnetics
- Physical Chemistry
- Combustion and Detonation
- Instrumentation
- High Power Pulse Electronics

Nuclear Propulsion & Radiation Phenomena

- Nuclear Weapons Effects
- Radiation Environment in Space
- Nuclear Power & Propulsion Applications
- Nuclear Radiation Laboratories

Send resume in confidence to: Mr. George R. Hickman, Engineering Employment Mgr., Dept. 4L-1

REPUBLIC AVIATION

Farmingdale, Long Island, New York

The Russians Score Again

Now that we have been permitted to see a photograph of the dark side of the moon by courtesy of the Soviet Academy of Sciences (Please credit Tass News Agency), do we sit back and wait for new triumphs from the Eastern side of the world?

And perhaps ponder on the words of our recent friendly visitor, N.S. Khrushchev on Oct. 6 at Vladivostok, after his return from the United States?

"The successes of the Soviet Union," he said, "are a vivid demonstration of the advantages of the socialist order over capitalism.

"Why is it that the United States, whose wealth and scientific and technical development have been a cause of universal amazement—why is it that that country is now repeatedly trying to launch a rocket to the moon, but instead of going to its target, it sinks to the bottom of the sea? It is not a case of their having insufficient dollars; they have plenty of dollars, they are richer. It is not a case of their having no materials; they have materials. It is not a case of their having no scientists; they also have scientists. What then do they lack? They do not have the kind of system that we have."

The Soviet boss makes a pretty good case, doesn't he? When he says we haven't the system, though, doesn't he really mean we haven't the will? That we have plenty of money, plenty of scientists, plenty of materials—but aren't using them?

That while the rest of the world applauds the Russian achievements, we sit back with a complacency that stems from heaven knows where and say these feats are not important, not significant? Just "another hunk of iron" up there?

(Khrushchev mentioned later in his speech that the Americans have begun to say "again" that they have more cars than the Soviet Union).

Somewhat in the same area, Russia made another significant announcement—its annual budget. In addition to reporting economic gains all along the way, it informs us that there will be no change in the Soviet military budget for next year.

The military funds set aside by the USSR have always been a little difficult to pinpoint, simply because no one but the Russians knows exactly what may be hidden where. But the major point is that the USSR is maintaining one mighty weapon, its military machine, while pushing ahead to new triumphs with the other, its space program.

At this moment the United States is working on its budget for the next fiscal year. It will be greatly concerned with the same two areas—its military machine and its space program.

There has been talk of a cut in the military—by as much as $2 billion. What turn of world events makes this an act of wisdom is difficult to see. The visit of Khrushchev? Perish the thought.

Of equal or perhaps greater importance is what the Administration does to the NASA budget; whether you approve of this fact or not, NASA is the all-in-all of our space program. Whether we catch up with the Russians, whether we succeed in space or fail, whether we compete or accept second place—it is all up to NASA.

This agency has recently inherited the Army's space team and that team's major project—a million-and-a-half-pound booster which might enable us to leapfrog some of the Russian space achievements. The team is experienced and capable and has chalked up some brilliant achievements.

Under NASA it can continue to be brilliant—if it gets the funds and the imaginative encouragement, the enthusiasm and the support that it should have.

These ingredients so necessary to success must come from the Administration, from our national leadership—as indeed all of NASA's programs must have such Administration backing if they are to go forward boldly and fruitfully. They cannot be starved and squeezed and neglected, financially or morally.

CLARKE NEWLON

Circle No. 20 on Subscriber Service Card. ⟶

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missiles and rockets

For additional information about any product or service advertised or mentioned in the editorial pages of this issue of Missiles and Rockets:

Use the attached prepaid reply cards. Circle numbers shown on the reply card that correspond with numbers appearing beneath items described. If no circle number accompanies the article or advertisement, give page number (and advertiser's name) on line provided at bottom of the card.

Your requests for information will be forwarded promptly to the companies concerned.

NEW PRODUCT BRIEFS

ƆWER CONTROL. A new line of
ɔwer control units utilizing magnetic
ating amplifiers driving sicilon con-
olled rectifiers has been introduced
y Magnetic Amplifiers, Inc. Desig-
ited Universal Power Control Units,
e new equipment will, to a large ex-
nt, replace conventional electrome-
ianical equipment such as amplidynes
id motor generator sets. Described
a "solid state marriage" of the mag-
itic amplifier and the solid state thyra-
on or silicon controlled rectifier, the
ɔwer units are said to offer a sub-
antial reduction in size compared to
vices now in use. They are reported
be approximately two-thirds smaller
id weigh four-fifths less than present
paratus performing the same func-
ɔn. The Magnetic Amplifiers, Inc.,
juipment provides voltage/current
gulation, AC servo motor control,
C motor speed and position control,
id temperature and light dimming con-
ɔl. Military applications for the power
its are found in missiles, jet and con-
ntional aircraft, ground support handl-
g equipment, and radar tracking sys-
ms. Industrial applications cover semi-
tomatic or completely automatic con-
ɔl system for processing, packaging,
d machine tool and material handling
erations, including conveyors, cargo
ndling and lifts.

cle No. 225 on Subscriber Service Card.

.FE-ARM INITIATOR. McCormick Selph
sociates is now marketing a new SAFE-
RM initiator to be used for missile or
cket high explosive destruct applica-
ns or placed in an igniter configura-
n for initiating solid and liquid pro-
llant rocket motors. Weighing less
in 0.50 lbs., the mechanism is capable
remote arming and disarming by
ans of an electrical signal either
rried by land lines prior to missile
nch or by telemetry when the missile
n flight. The initiator may be changed
m the SAFE to ARM condition or
m the ARM to SAFE condition re-
tely and may be manually disarmed
the unit. Manual arming, however, is
possible, resulting in safety of per-
nel and equipment. The ARMED or
FE condition is shown by a red in-
ator light either at the unit or at the
note location. The case is anodized
minum and all electronic and explo-
e components are potted in foamed
stic. There are no moving parts in the arming system and the explosive train is series-paralled for maximum reliability. Arming can be accomplished in seconds using fractions of an ampere of electricity. Arming and firing voltages can be varied to meet arming system requirements. The unit may be mounted on any type surface through the use of Twist-Loc or equivalent fasteners: the primary advantage being the rapid installation of the unit under any condition and without the use of special tools. The SAFE-ARM initiator is permanently sealed prior to installation and no moisture or other damage can occur. This condition may be held indefinitely as is necessary in many missile firing operations. A single Bendix Pygmy connector is provided for connection to all external electrical circuitry. A full range of qualification and reliability testing is being accomplished and the unit will operate at 99.85% reliability under any environmental condition encountered by missiles, rockets and space vehicles.

Circle No. 226 on Subscriber Service Card.

BUTTON SWITCHES. A new line of miniature push button switches for console and instrument applications has been announced by Transistor Electronics Corporation. Designed to match their line of indicator lights, the MBS series of switches feature gold-plated contacts with wiping action to assure positive trouble-free operation and low contact resistance. Rated at 100 ma with a life of 500,000 operations, the MBS is offered with form A, B or AB contacts. The unit mounts with a single nut in a ⅜" hole and is available with all standard button colors.

Circle No. 227 on Subscriber Service Card.

DIAL READER. Parabam, Inc. has announced the production of an Angle Dial Reader designed for precision semi-automatic reading of elevation-angle and azimuth-angle dials on cine-theodolite and radar data film. By projecting the dials on a viewing screen and by utilizing a cross wire measuring system, the machine provides a rapid, accurate and efficient means for reading angle dials. An integral keyboard and selector switches are provided for entering additional data and the information is semi-automatically recorded on punched cards.

Circle No. 228 on Subscriber Service Card.

MISSILES AND ROCKETS

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● **New Missile Products**

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MISSILE LITERATURE

SOLDERLESS WIRING DEVICE. Showing the user how to choose the best kind of terminal for his particular wiring application, a new brochure is offered by ETC Inc. A wide choice of basic types of electric terminals and connectors is shown, ranging from the "ring" and other standard tongue designs through multiple-wire conectors and quick-disconnects. The five ETC barrel styples are illustrated, including insulated, non-insulated and vibration-proof styles. Performance features of each are compared. A cutaway view shows construction details of a typical terminal. All ETC terminals feature the full ¼" barrel length that eliminates loss of time finding a critical crimping location, eliminates squeeze-outs and shearing, allows a wider crimp for extra-strong connections.

Circle No. 200 on Subscriber Service Card.

STAINLESS STEEL. A new by-monthly publication for users of stainless steel is being produced by the Stainless and Strip Division, Jones & Laughlin Steel Corp. Entitled "Explorer," its purpose is to review new developments and applications of stainless for industrial, commercial and defense products. The Explorer is designed to alert readers to potential production economies, new product and profit opportunities, and possible methods of improving existing products. Variations on familiar uses of stainless steel as well as dramatic new applications are detailed with the extensive use of art and photography. Special coverage is planned for new applications which are the result of increased demands for high strength, corrosion resistance and heat resistance.

Circle No. 201 on Subscriber Service Card.

SAFETY STARTER. Six important safety features of Westinghouse Electric Corp.'s new Type L combination safety starters are discussed in a new booklet which they call "Industry's Safest Line of Combination Starters." Type L starters, designed to meet recommendations of the Joint Industries Council, are used to control industrial equipment such as heavy machine tools.

Circle No. 202 on Subscriber Service Card.

COLD HEADING WIRE. Universal-Cyclops Steel Corp. announces the availability of a new four-page brochure on stainless steel cold heading wire. This new brochure compares the cost, corrosion resistance, and cold heading characteristics of the commonly used grades of stainless steel cold heading wire.

Circle No. 203 on Subscriber Service Card.

WELDING NEWS. A 7500 ton press ram overlaid with 5000 feet of aluminum bronze filler metal is described in the third quarter 1959 issue of the Ampco Welding News. Also included in this issue of the publication are articles describing the repairing of cast-iron gears and advantages and applications of Ampco's new line of extruded rectangles.

Circle No. 204 on Subscriber Service Card.

MAGNET WIRE. Anaconda Wire and Cable Co. announces a publication to help manufacturer, maintenance and repair firms choose magnet wire for Hermetic Motors. Titled "Enameled Magn
Wires for Hermetic Motor Applic
tions," the 19 page booklet includes
table of test data for each of t
types of insulation Anaconda reco
mends for hermetically sealed mot
service. These are anavar, anather
epoxy, formvar, and lecton.

Circle No. 205 on Subscriber Service Ca

PROCESSOR. Details of MicroSADI
a high-speed analog-to-digital proc
sor are presented in an illustrated, fo
page bulletin offered by Consolidat
Systems Corp., subsidiary of Conso
dated Electrodynamics Corp. The m
chine acquires, digitizes and stores da
at a maximum rate of 10,000 sampl
per second. Operation, design deta
and specifications are described.

Circle No. 206 on Subscriber Service Ca

CAPABILITIES. American Bosch Ar
Corp. has issued a facilities and cap
bilities brochure which outlines the
gineering services and products
automatic measurements and control
processes by electronic and elect
mechanical techniques which it has p
vided both industry and the milita
Various types of ground support equi
ment and production test equipment
both missile and aircraft systems, a
test equipment for automotive industr
use are depicted.

Circle No. 207 on Subscriber Service Ca

WELDING WIRE. A revised edition
the Air Reduction Co.'s welding w
pocket guide has just been publishe
The 84-page booklet includes the lat
information on Airco's line of g
shielded metal-arc welding wires,
cluding data on the A675 steel wire a
the new A666 steel and A556 aluminu
The guide provides answers to questi
concerning the steel, aluminum, cop
and copper base, stainless steel, titani
and special welding wires used with
Reduction's Aircomatic welding proce
The guide contains technical informati
such as chemical composition, mecha
cal properties, and operating pro
dures, as well as wire diameters a
packaging data.

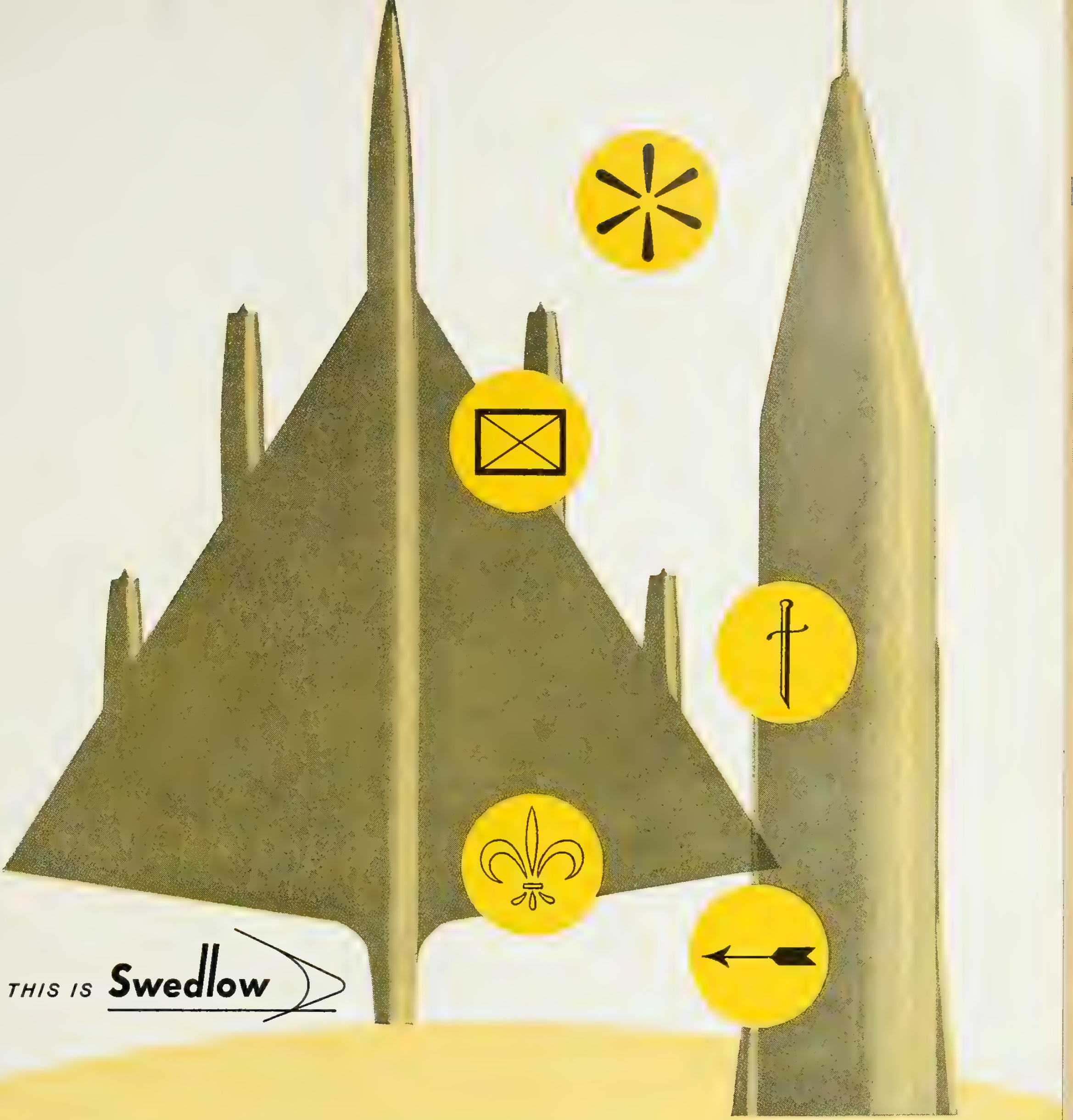
Circle No. 208 on Subscriber Service Ca

ELECTRICAL CONTACTS. A 4-pa
catalog published by Gibson Elect
Company, describes materials, prop
ties, forms and uses of its line
electrical contacts. Discussed are co
tacts manufactured from fine silver, c
silver, palladium, gold, platinum, all
known as Gibsalloys," and many p
dered metal compositions designated
"Gibsiloys." A feature of the catal
is an outline showing contacts for v
ous applications such as contractors,
struments, circuit breakers, switches a
many others.

Circle No. 209 on Subscriber Service Ca

NOISE GENERATOR. A four page b
letin describing a 166 decibel Acous
Noise Generator developed by the A
Research and Advanced Developm
Div. is now available. The genera
uses an electro-mechanical transdu
of moving-coil type producing 166
of random noise and 170 db at discr
frequencies.

Circle No. 210 on Subscriber Service Ca



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← **Plastic Glazing.** Stretched, as-cast, monolithic and laminated acrylic windows, canopies, windshields, with emphasis on high temperature glazing applications. Optically polished, tough, light weight, resistant to fracture.

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NOVEMBER 9, 1959

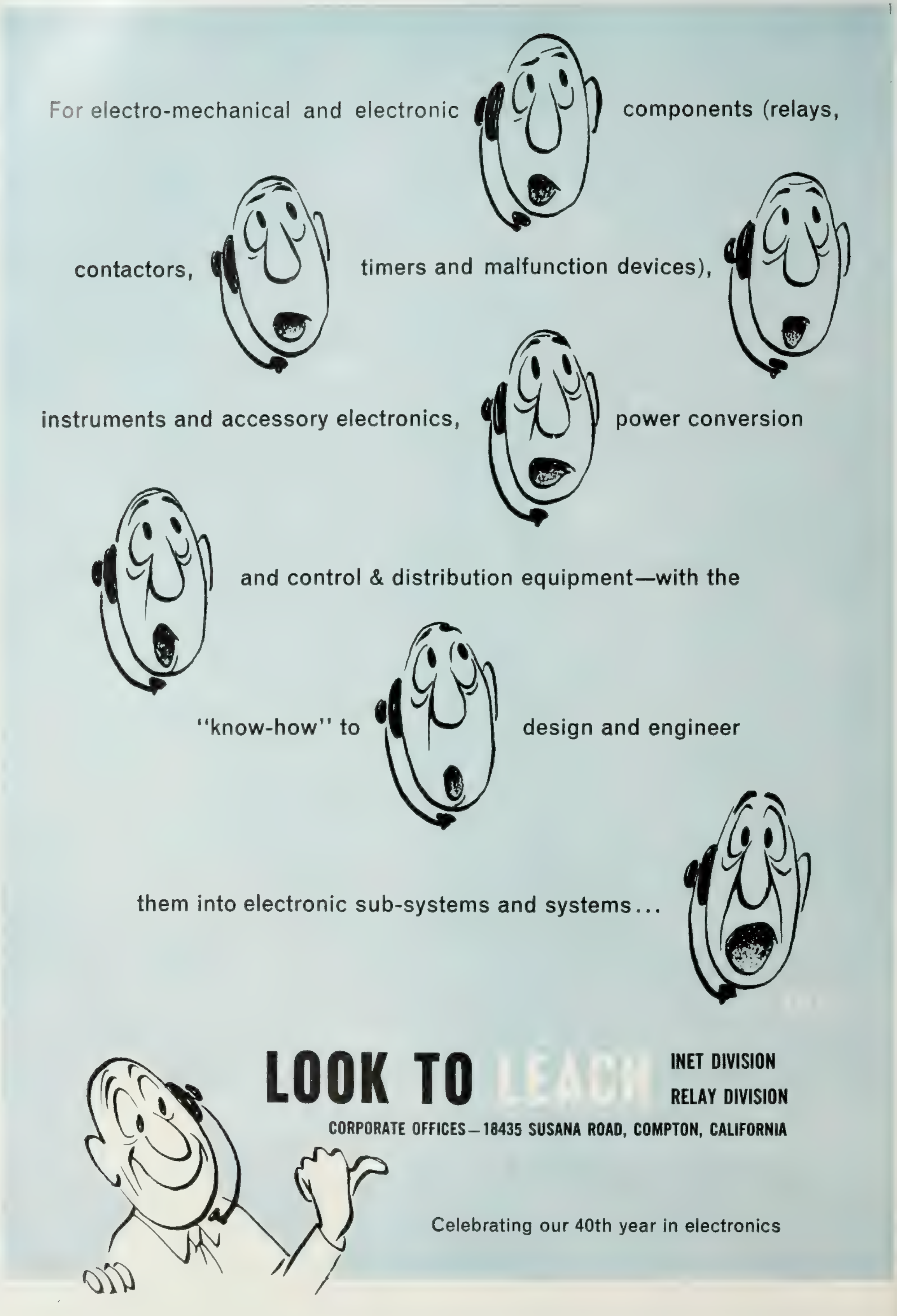
INFANTRYMAN AND LACROSSE

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

NASA Awaits Funds for Space Job .12
IR Cooling Problems Find Answers .20
M/R's Astrolog—Second Edition . . .25

AN AMERICAN AVIATION PUBLICATION



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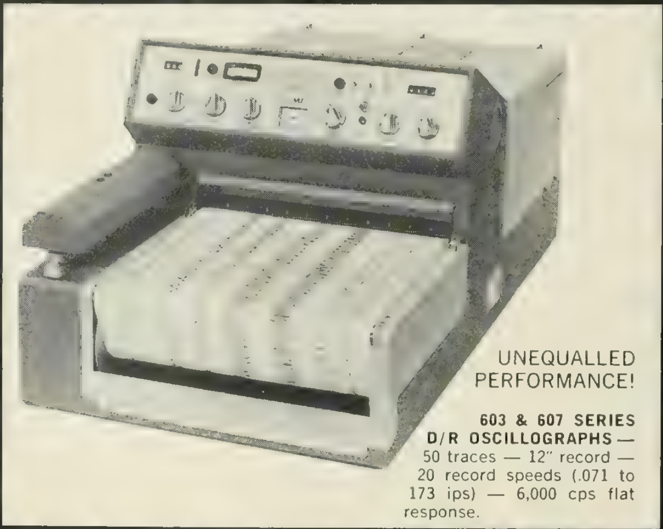

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missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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NOVEMBER 9 HEADLINES

NASA Waits for Money To Do Its Overall Space Job
The civilian space agency moves into the dominant role in U.S. space efforts and will have the engines and vehicles to do the job—if the Administration and Congress provide funds running into billions of dollars 12

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Rocket Society's Washington Meeting To Draw 7000 .. 15

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IR Industry Is Solving Its Cooling Problem
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But unless steps are taken to prevent waste, supply will not meet demands beyond 1980 30

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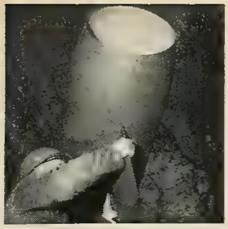

COVER: Martin *Lacrosse* is replacing conventional Army artillery. Three more *Lacrosse* battalions will be activated early next year, making a total of seven operational units.

AERIAL View of Sunnyvale, Calif., plant of Lockheed's Missiles and Space Division. LMSD is the biggest employer in the San Francisco Bay's missile effort, surveyed on p. 16.

LINDE makes this liquid N_2 feed-vacuum insulated line in cooling infrared detection cells. This and other developments are rapidly solving IR's cooling problems. See p. 20.

HELIUM is produced in liquid form by the National Bureau of Standards laboratory at Boulder, Colo. Helium supply is now enough for essential needs, but this may well be temporary. See p. 30.

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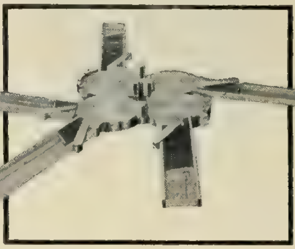

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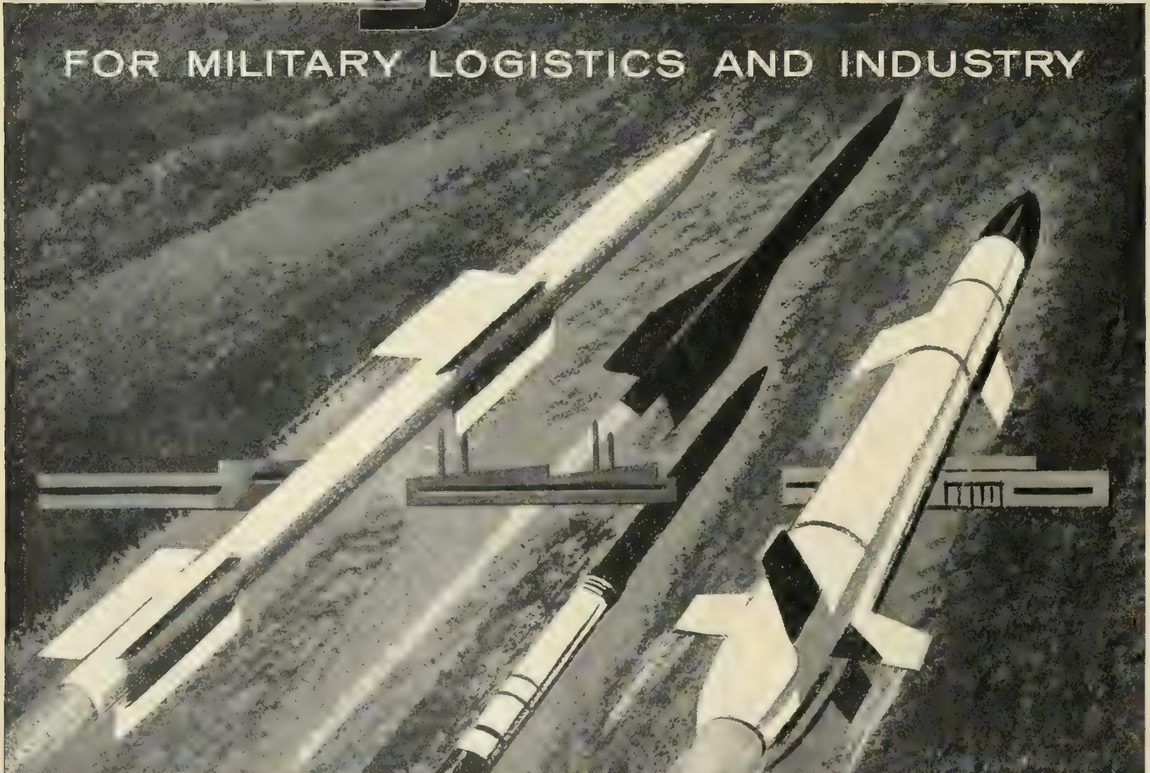
FOR MILITARY LOGISTICS AND INDUSTRY

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Washington Countdown

IN THE PENTAGON

Long-delayed Project *Dyna-Soar* . . .

may well soar out of the Air Force and land in NASA's lap along with the huge three-stage *Saturn* rocket. NASA is looking at proposals to use *Saturn* for launching winged space vehicles. That would produce a *Dyna-Soar* in mufti . . . and give the budget-minded Administration an opening to scratch the proposed military program and substitute a stretched-out civilian one.

• • •

Missile-minded wits . . .

have already come up with a possible civilian name for a civilian *Dyna-Soar* project. They've dubbed it the *Von Braunto-Soar.*

• • •

The next *Transit* launching . . .

is scheduled for February. The ARPA-Navy navigational satellite is still expected to become the nation's first military satellite system despite the failure of the first launching in September.

• • •

An advanced *Hawk* . . .

is understood to be under development by the Army. The improved **Raytheon** surface-to-air missile would have more speed and range than the 20-mile range models being deployed with field units.

• • •

No speedup . . .

in construction of *Polaris*-launching submarines will be included in the tight new FY 1961 budget. The Navy will have to settle for three more of the missile-launching nuclear subs, bringing to 12 the number authorized. The Navy is expected to ask for a total of about $900 million for the *Polaris* program —$300 million more than it has under the FY 1960 budget.

• • •

Air-launched tactical satellites . . .

are still under study by the Navy despite the chill reception repeatedly given the idea by ARPA. However, reports that the Navy actually has launched a small satellite from a jet are greatly exaggerated. At best, Navy researchers scored a slim "maybe."

The first *Pershing* . . .

launchings from Cape Canaveral are expected within about a month. The launching facilities for the 700-mile range **Martin** missile will be completed in a few weeks. The solid missile will replace the Army's liquid *Redstone.*

ON CAPITOL HILL

A broadside of investigations . . .

into the nation's space programs are expected to be launched from committee hearing rooms as soon as Congress convenes in January. At least four are expected in the House . . . possibly two in the Senate.

• • •

Some early spade work . . .

will be done by an eight-member delegation from the House Space Committee. They plan during the next few weeks to inspect missile plants and military installations from White Sands Proving Ground, N.M., to Vandenberg AFB, Calif.

AT NASA

Seventeen space docs . . .

are being enlisted by NASA for assignment around the world at telemetry stations. They will monitor the results of biomedical space experiments and Project *Mercury.*

• • •

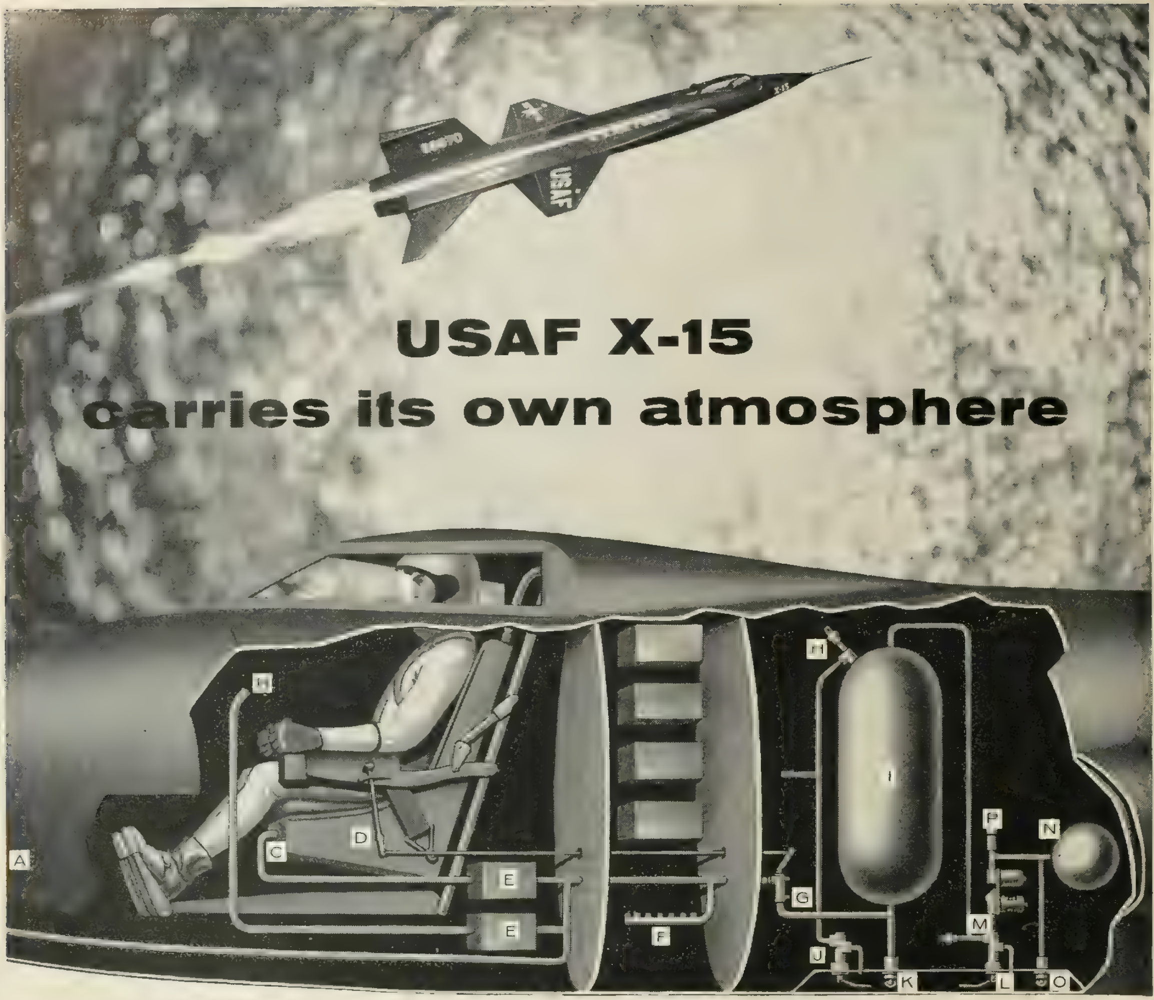
The *Vega-Centaur* schedules . . .

so far are reported unaffected by the steel strike. However, the strike continues to slow construction of the *Vega* launching stand at Cape Canaveral.

• • •

Pass the *Luna* . . .

is a new game being played at NASA. *Luna* is described as a space ship the size of the Empire State Building. A space agency engineer says NASA is developing one; NASA says it isn't. But the engineer's statement is reported to have been passed on by his superiors before he made it.



USAF X-15 carries its own atmosphere

AN ENTIRELY NEW CONCEPT IN PRESSURIZATION AND COOLING . . . A *Nose cone cooling,* **B** *Cabin pressurization and cooling,* **C** *Suit pressurization and cooling,* **D** *System control,* **E** *Heat exchangers,* **F** *Electronic bay (cooling and inerting),* **G** *Supply valve,* **H** *Nitrogen relief valve,* **I** *Liquid nitrogen storage tank,* **J** *Liquid nitrogen vent valve,* **K** *Liquid nitrogen filler valve,* **L** *Helium vent and buildup valve,* **M** *2-stage helium regulator, 4400-65 psi,* **N** *High pressure helium storage,* **O** *High pressure helium filler valve,* **P** *Helium relief valve.*

● *The AiResearch Pressurization And Air Conditioning System* in North American's X-15 is a radical departure from normal pressurization and cooling techniques, also pioneered by AiResearch, which up to now have utilized outside air surrounding the aircraft. When the X-15 manned spacecraft climbs into space beyond the earth's atmosphere, it will carry its own atmosphere in the form of liquid nitrogen dispensed through a self-sufficient AiResearch pressurization and air conditioning system for the pilot and vital equipment.

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Industry Countdown

MANUFACTURING

Expect railroad launch . . .

production contract for **Boeing's** *Minuteman* to run around $50 million—just for the special missile car. Current planning calls for something like 100 missile trains, each with five missile cars and each of the cars costing about $100,000. Approximately 10 company teams in the competition are expected to submit cost proposals this month.

• • •

Before the year is out . . .

the Army probably will put its *Sergeant* artillery-type 75-mile successor to *Corporal* on the operational list. The **Sperry Rand**-manufactured missile is now in full production and in the final test stage with production-type launcher-erectors.

• • •

NASA will fire . . .

four NERV (nuclear emulsion recovery vehicles) payloads from PMR next summer. **General Electric's Missile and Space Vehicle Department** in Philadelphia has the $560,000 contract to produce NERV, which is designed for more extensive study of the earth's radiation belts.

• • •

Cost of hard ICBM bases . . .

is holding on even keel. In the $267 million released by AF recently for construction of facilities, *Titan* bases are being funded for about $43 million apiece. The four latest receiving money are at Beale AFB, Calif.; Mountain Home AFB, Ida.; Ellsworth AFB, S.D.; and Larson AFB, Wash. Funds also were released for *Atlas* bases at Lincoln AFB, Neb.; Shilling AFB, Kan.; and Warren AFB, Wyo. Each of them gets about $30 million.

• • •

Researchers are complaining . . .

there is still an urgent need for more cataloguing of the boundlessly increasing volume of technical literature. Much time and funds are being wasted in duplication of R&D. The situation is so bad, says one East Coast technician, that sometimes it is easier to get required data from Russian translations—rather than search our own sources.

PROPULSION

Future of AF high-energy . . .

fuel plant run by **Olin-Mathieson** at Modeltown, N.Y., is in doubt. The $35-million facility has been put on the idle list for screening and possible sale by the General Services Administration.

• • •

New heat treating . . .

facilities designed for processing large diameter solid rocket motor cases are being built by **Lindberg Steel Treating Co.,** Melrose Park, Ill. Project has received OCDM fast tax write-off certification on 60% of the $750,000 total cost.

• • •

Industry is still waiting . . .

and not too hopefully for a go-ahead on a two-year-old AF project called *Nomad* designed to land 1100 to 1200 pounds of payload on the moon. The two-stage vehicle would employ *Atlas* as a booster and utilize a hydrazine/-fluorine engine in the second stage.

ASTRIONICS

Silk screen printing . . .

of electrical circuits has been developed by **Bell Telephone Laboratories.** The process, which doesn't require adhesive, prints a paste of partially fused glass and copper oxide—then reduces the oxide to leave pure copper.

• • •

Search for better . . .

gravitational constant is under way at National Bureau of Standards. The latest approach abandons the conventional Aetvos pendulum method (which has produced inconsistent results) and uses acceleration during free fall in a vacuum.

WE HEAR THAT—

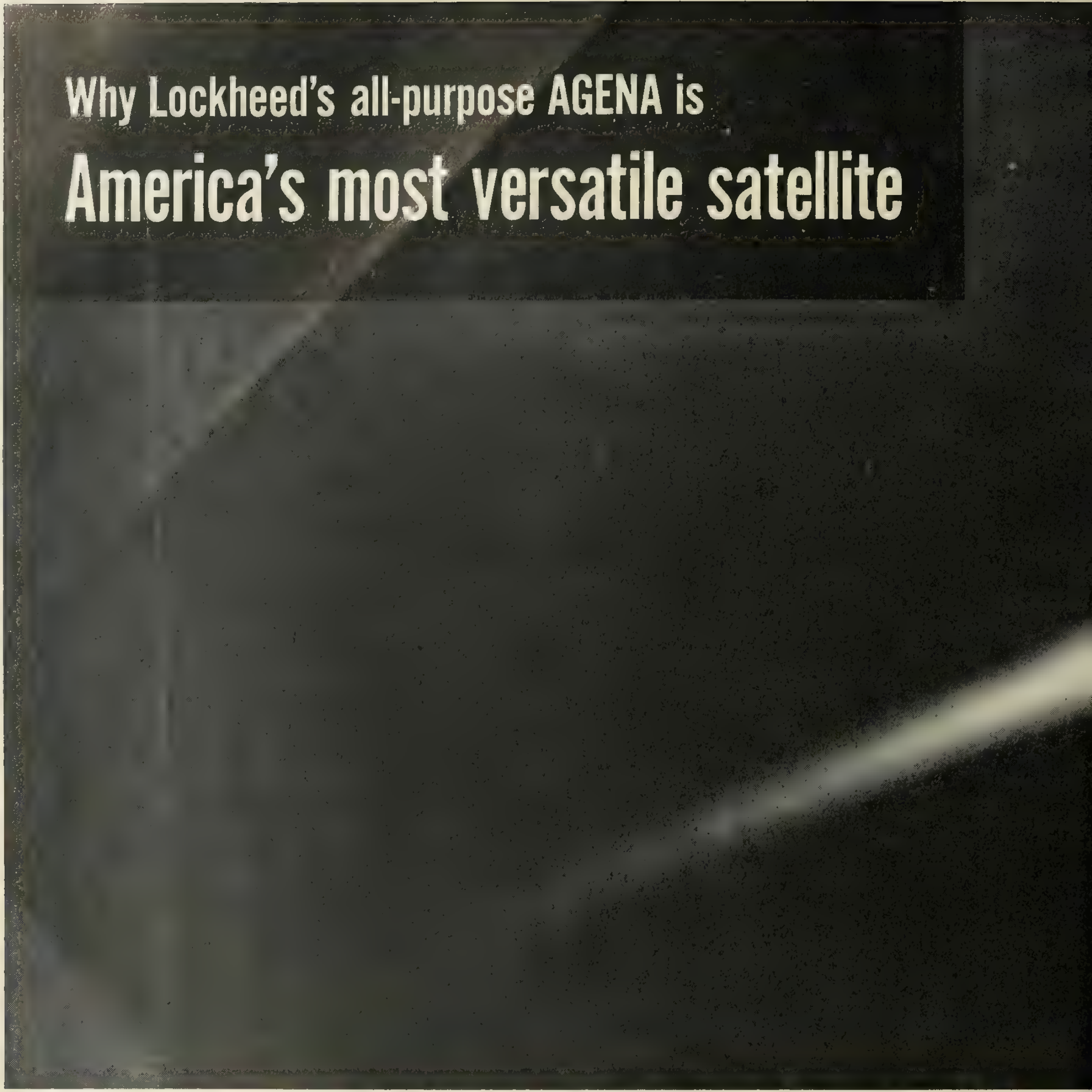
The Martin Co. is interested . . .

in obtaining control of **General Precision Equipment** . . . Rumors are cropping up that **Boeing** would like to buy **Bell** . . . Joining the undersea warfare ranks: **Cleveland Pneumatic Industries,** with a solid-propellant underwater propulsion system . . . a recent study by **Opinion Research Corp.** of 622 technical personnel and 105 persons in management of six companies showed nearly 75% of the scientists and engineers thought their abilities were misdirected; 90% thought they were underpaid . . . Thrust of the **Rocketdyne** F-1 engine in current tests is in milleseconds. The big NASA booster, fully developed, will have one million pounds thrust . . .

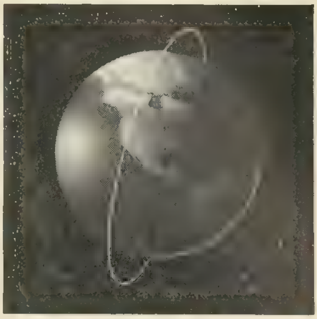
More About the Missile Week on Page 44.

Why Lockheed's all-purpose AGENA is

America's most versatile satellite



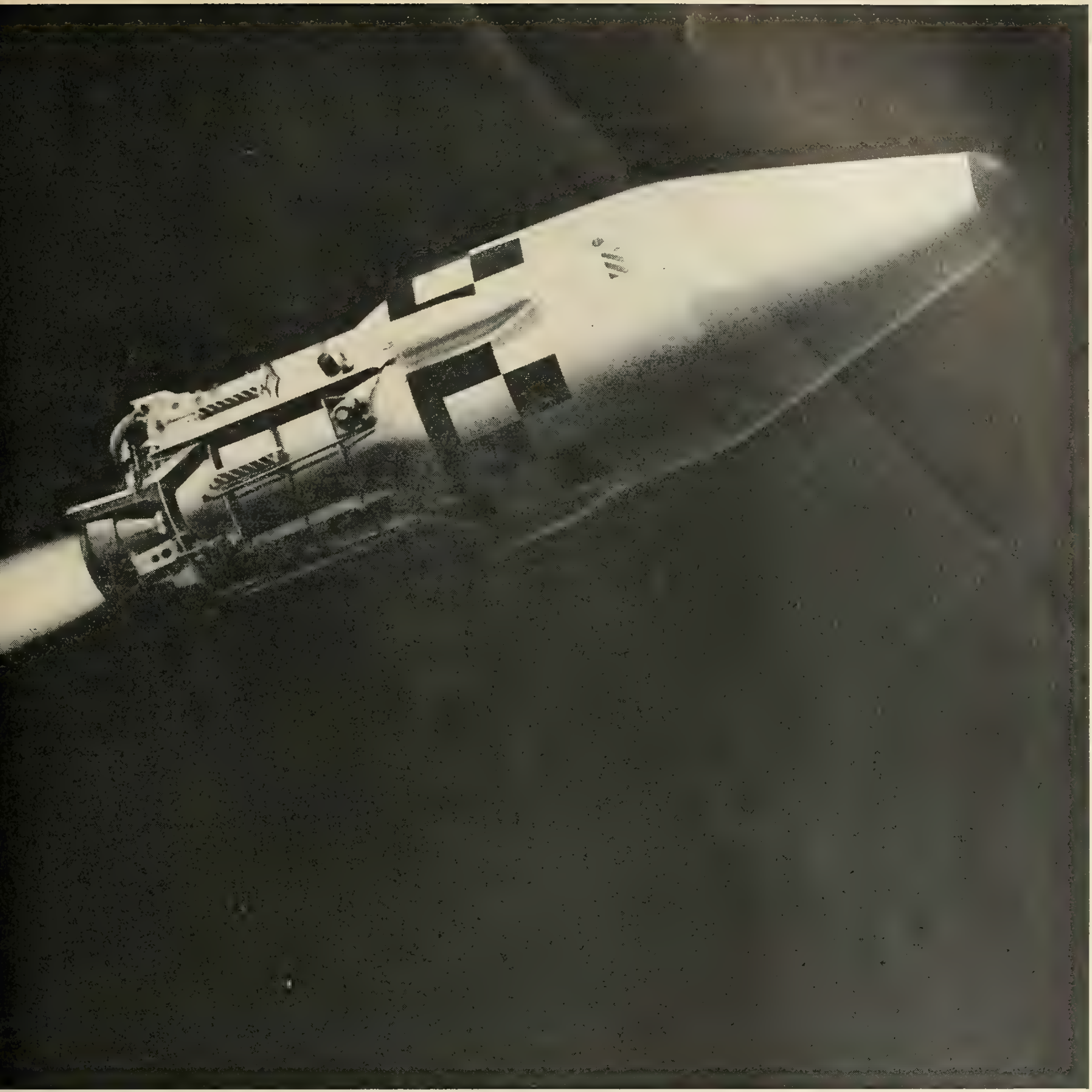
Discoverer Program "Firsts" by AGENA Satellites



First to be put on a polar orbit. Only the Agena, with its horizon-scanner and its response to signals from earth, can be placed on a precise, predicted orbit over the pole.

First to be controlled on orbit. The Agena is also unique in its ability to be turned 180° to a tail-first position and tilted to a 60° downward angle for capsule ejection.

First to carry new systems into spac
The Agena has proved out man
devices — control, communicatio
telemetry, life-sustaining — to be use
in other advanced space program



he Agena is the largest and heaviest true satellite the U.S. has ever put on orbit. It is the only satel- te that can be put on a precise, predicted orbit...that can be controlled while on orbit...that can ject a recovery capsule. It can carry a wide variety of very heavy and specialized payloads. The gena satellite is now used exclusively in the Discoverer Program, directed by the Advanced esearch Projects Agency and managed by the Ballistic Missile Division of the U.S. Air Force.

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Two-year fight ended . . .

NASA Emerges as U.S. Space Force

Space Agency has the resources and vehicles to catch Russia if the Administration and Congress provide the money.

Five little . . . four little . . .
three little Indians
And then there was one . . .

by C. Paul Means

WASHINGTON—The National Aeronautics and Space Administration, after two years of infighting which saw as many as five cooks in the space kitchen—each with its own recipe—has now emerged as the one agency responsible for U.S. space prowess.

The big question remaining about the now streamlined space program is how fast and how far will the Administration and Congress allow it to proceed.

• **Space setup**—A series of transfers during the past year culminating with the ABMA and Project *Saturn* transfer this month, has given the nation the following space setup:

—The Army and Navy space facilities, along with their scientists and technicians, have been transferred to NASA. If either service feels they need a necessary tool or weapon in space, they will have to get DOD's R&E Director Dr. Herbert F. York to okay the project, the Air Force to launch it, and NASA to provide any vehicle bigger than *Atlas* or *Titan*.

—ARPA's space booster and vehicle programs have been transferred to NASA.

—The Air Force now has the military booster mission in space (set at 600 miles).

—With few exceptions, NASA is now charged with the development of future space boosters, upper stages, vehicles, the projects which will explore near space, and all of space more than 600 miles away.

And with the Russian space lead calculated as being anywhere from two to five years, NASA will not have an easy job, and will need the cooperation of the Administration and Congress (principally in the form of dollars) to perform it.

How all this came about is not clear, and subject to many interpretations. As late as this fall responsible experts of space research and government were saying that the bulk of the space programs would fall to a military organization rather than NASA because it is easier for a military organization to get money out of Congress. Principal reason for the consolidation under NASA is that Russian successes demanded that the space program's responsibility be given to one agency. NASA was judged to have the greatest resources and capability for directing such a program.

• **NASA resources**—In existence a little over a year, the NASA table of organization is now firm. The tools which it can use include the research and development laboratories inherited from the old NACA. These are:

—The **Langley Research Center** at Langley Field, Va. The oldest NACA facility, its areas of research are aerodynamic heating, hydrodynamics, and structure loads.

—The **Lewis Research Center** at Cleveland, O. Lewis's staff is developing the chemical, nuclear, and electric rocket propulsion systems of the future.

—**High-Speed Flight Station** at Edwards Air Force Base, Calif. Now engaged in research of the rocket-plane *X-15*.

—**Ames Research Center** at Moffett Field, Calif. Micrometeoritic impact and aerodynamic heating of space materials are among the principal research efforts.

From the Army, NASA got the **Jet Propulsion Laboratories,** and will get the Development Operations Division of the Army's Ballistic Missile Agency. Long known for the work on propulsion, tracking and guidance, JPL was a major partner in the Army's *Jupiter-C* and *Juno II* experiments.

ABMA, the latest and most glittering of jewels in NASA's crown, consists of over 4000 rocket personnel led by a nucleus of German scientists who developed the *V-I's* and *V-II's*, and the *Jupiter-C's* and *Juno II's* which launched the free world's first earth satellite and only sun satellite into orbit.

If Congress confirms the President's action next year, ABMA will join NASA's group of space flight laboratories. NASA will appoint a director over Wernher von Braun because the German scientist does not want the administrative post.

From the Navy, NASA got the *Vanguard* team, including valuable space electronics personnel from the **Naval Research Laboratories.**

New agencies formed by NASA include the **Goddard Space Flight Center** and the **Plum Brook Research Reactor**

PAST . . .

JUNO II—this workhorse still serves until newer vehicles arrive.

facilities at Sandusky, Ohio. Goddard will move into its new headquarters near Washington next year. Personnel include the 200 personnel transferred from the Navy's *Vanguard* program and the Project *Mercury* team. This group will do overall research into space flight, and control the manned space program. The Plum Brook facility, to be ready next year, includes rocket test research facilities, and a $10,735,000 reactor under construction since 1956.

NASA can also call on the Air Force's **Space Technology Laboratories** as it has done in the *Thor-Able* and *Atlas-Able* shots. The quality of work done by this organization is demonstrated by the "paddlewheel" payload of *Explorer VI*.

Behind these agencies lie the many private industries who helped the individual services develop their missile and space programs. As the space budget grows, these industries should be able to get substantial space work to offset the decline of government contracts in other fields such as military aircraft.

- **Have program, need money**—The NASA space program will have the engines and vehicles to do the job—if the Administration and Congress give them money to develop them when needed in the quantity needed.

These vehicles include:

—*Scout*. A cheap, reliable solid-propellant vehicle which can launch a 300-lb. payload into a 200-mile orbit, *Scout* under prime contractor **Chance Vought** is expected to cost only $500,000 per vehicle and should be ready by this summer. This vehicle will be the workhorse of low-altitude satellite orbit research. The Air Force will use this NASA vehicle under the name S609.

—*Thor Delta*. Capable of putting 65 pounds of useful payload in orbit around the moon and of rough landing 50 pounds on the moon, *Thor Delta* under management of STL is expected to be ready early next year.

—*Vega*. Under the direction of JPL and **Convair,** *Vega* is an advanced vehicle capable of circular earth orbits, orbiting a 1,000 lbs. around the moon, and 260 pounds around Mars or Venus. First flight of this vehicle is expected next fall.

—*Centaur*. Similar to *Vega* except with a high energy liquid hydrogen-LOX second stage **(Pratt Whitney)**, *Centaur* almost doubles *Vega's* payload capabilities and could orbit 275 pounds around the moon and then return the payload to earth.

—*Saturn*. The first space vehicle in the U.S. arsenal capable of operational manned space flight. With a booster consisting of a 1½ million pound thrust cluster of eight **Rocketdyne** engines, *Saturn* can lift heavy manned stations into low orbits. It would allow the U.S. to put up a space communication center, a meteorological observation center, and a scientific research center. Under the direction of ABMA, *Saturn* can also launch large unmanned payloads into deep space and to the planets. With funding, it could be ready in two years.

—*Nova*. A cluster of 1-million-pound engines being developed by Rocketdyne, *Nova* could make a manned landing and a return from the moon of 2,100 payload, orbit Venus with a 15,000 lb. payload, or land on Venus and return with a 4500 payload. Estimated operational date for this vehicle is 1965.

Until these newer vehicles come along, NASA will rely on the old standby *Juno-II*, and on the makeshift missiles *Thor-Able* and *Atlas-Able*. Though neither of the *Able* vehicles have the attractive design characteristics of space vehicles because their upper stages are not properly mated to their missile boosters, both have the capability of performing significant missions. The *Atlas-Able* will attempt a payload around the moon in the near future, and the *Thor-Able* will attempt to orbit a payload around the sun with a transmitter powerful enough to be heard further than 50 million miles.

- **How much money?**—Now that the U.S. has centralized and stream lined the command of its scientific space program, how much money will be needed to put it on a competitive basis with Russia's?

Figures given vary, but the consensus is that a program designed to obtain the vehicles now under development as quickly as possible, and to continue an adequate program to develop the next generation space engines operating on electrical and nuclear propulsion will cost over $1 billion in fiscal '61, and substantially more each year after that.

Estimates are that Project *Saturn* will cost $600 million more. If NASA is to meet the feasible two year completion date for this vehicle, $250 million will have to be spent in Fiscal '61, and $350 million in Fiscal '62.

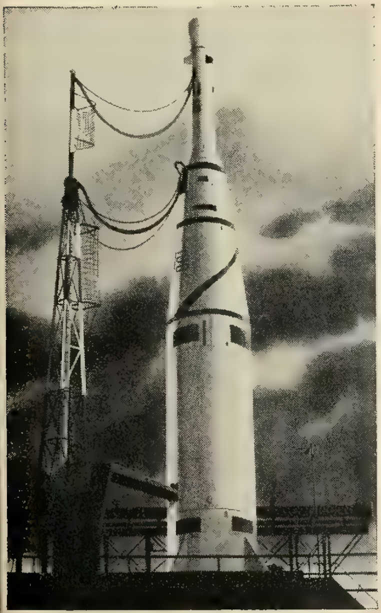
Vega and *Centaur* will need according to NASA figures, an extra $48.5 million during the next two fiscal years, and *Scout* will need at least an extra $15 million as it goes into production.

Estimated cost of *Nova*, if newer types of space engines do not make it obsolete and curtail its development, will be over a billion dollars during the next five years. Present NASA scheduling calls for $60 million for the project during the next two years.

Project *Mercury*, which is costing NASA more than was estimated, should be funded for close to $100 million in the Fiscal '61 budget.

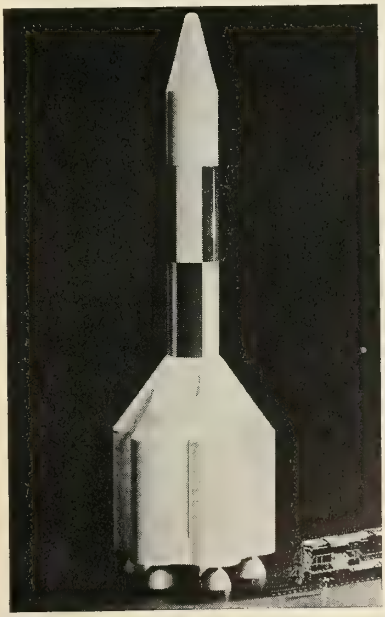
Within the next decade when nuclear and electric engines come into use, and space missions become manned, larger, more complex, costs can be expected to spacerocket.

PRESENT . . .



THOR DELTA—goes into service early next year.

FUTURE . . .



SATURN—Over two years off, makes significant manned payloads possible.

Irvine Says Single Service Is Vital

WICHITA, KAN.—Blunt-spoken Clarence S. (Bill) Irvine took an incisively critical look at the nation's military and civilian leadership last week and found it woefully lacking in direction and purpose.

In his first sweeping defense appraisal since becoming an **Avco** vice president earlier this year, the former AF Deputy Chief of Staff for Materiel declared that the United States must have a single military service, better education and a streamlining of our space and defense posture to keep from being overwhelmed by Russia.

"It now becomes crystal clear," the retired lieutenant general told the Institute of Aeronautical Sciences, "that a simple and positive, civilian and military command structure is essential to survival."

Below NASA and "at the top" of DOD, he said, "we must get quickly to a modern streamlined organization, greatly reduced in numbers of divisions and numbers of people. A simple, understandable and operable military type line and staff organization."

He said taxpayers are footing the bill for an "unreasonably expensive and unwieldy" air operation comprised of five air forces—Army, Navy, Marines, Air Force and commercial airlines. And many millions of dollars are being frittered away, he contended, in duplicate production and research programs as the nation moves into operations in space.

Irvine advanced this plan for reorganizing the military:

- Create a single service with functional divisions for land, sea and aerospace with a single uniform and under a single commander—who would correspond to the present chairman of the joint chiefs of staff.
- Creation of single worldwide commands for the strategic air function and for air defense.
- Appropriate commands for control of surface naval operations and undersea warfare and another for all troop operations on land. Each command would be headed by a vice commander under the senior military commander.

For each of three functional areas of land, sea and aerospace, specialized engineering, procurement, production and support operations would be set up. "Halfway measures are not enough," said Irvine. "We must do the whole job if we want results—in time."

The only way that unification will be achieved is through "hardhitting" free press informing and educating Americans "in the actions necessary for survival." Failure to pursue an aggressive course in this direction, Irvine warned, will mean "we shall continue to look at the tail lights on the Russian caboose—always just rounding the corner ahead of us—and one day we will be teaching Russian and Chinese as the major lingual requirements in our universities."

While refusing to take any direct cracks at current policies of the Eisenhower Administration, Irvine made it clear that he believes them to be highly unsatisfactory. He said the Nation "must throw off the shackles of the past in our approach to the future."

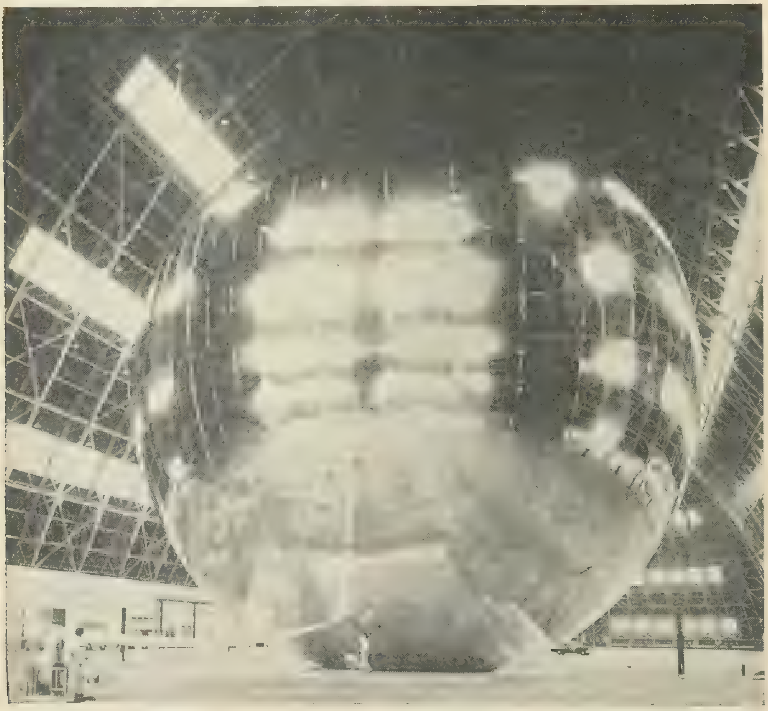
"We need productive creativeness, real solid results, rather than complacency."

He called for "bold, clear thinking unfettered by politics, geographical pressures, by individual corporation limitations, or sheltered university curricula." The major areas sorely in need of this approach:

- **Space propulsion**—The development of materials for nuclear ion, plasma and solar power plants are all "essential programs which must be properly supported and financed."
- **Air and ground transportation**—It is imperative that all air traffic communications and flight control systems—civilian and military—be aligned under single civilian control.
- **Education**—Women are a tremendous, untapped reserve of brainpower available for training in the sciences. Moreover, well-educated women will set higher educational standards for their children—thereby elevating the general standard of education.

Irvine sharply criticised "discriminatory" practices of government agencies—including NASA—in tying up previously-developed proprietary rights of companies under defense contracts. And he said there is an "absolute necessity" for the proper and appropriate utilization of "trained active and retired military men of all services."

NASA Sphere Gets Ejection Test



A 100-FOOT-diameter sphere like the one above was launched by a sounding rocket to 250 miles over Wallops Island recently. Designed to test satellite drag at high orbital altitudes, the balloon payload's ejection mechanism functioned perfectly, allowing the balloon to be seen over much of the East Coast.

7000 to Attend ARS Convention

Five Russians due at Nov. 16-19 sessions; McCone, Von Braun among featured speakers

by Jay Holmes

WASHINGTON—More than 7000 rocketmakers, industry representatives and government officials are expected to attend the fourteenth and biggest annual meeting of the American Rocket Society here Nov. 16-19.

The delegates will include five Russians, headed by Prof. Leonid Sedov, president of the International Astronautical Federation. They will be the first Russians ever to attend an American technical meeting devoted to space flight.

John A. McCone, chairman of the Atomic Energy Commission, will be the featured speaker at the Wednesday night Honors Dinner. Luncheon speakers will be: Monday, Wernher von Braun; Tuesday, Air Force Brig. Gen. Homer A. Boushey; Wednesday, Dr. William H. Pickering of the **Cal Tech Jet Propulsion Laboratory;** Thursday, George P. Sutton, of the Advanced Research Projects Agency. Gen. Boushey replaces Maj. Gen. Bernard A. Schriever.

- **Rocket report**—A Monday evening session on "Latest Events in Space Flight" will present late reports on data obtained from satellites and information of firings made as a part of International Rocket Week. Dr. Abe Silverstein of the National Aeronautics and Space Administration will be chairman.

On Tuesday evening, the ARS National Capital Section will present a panel discussion of "Planning the Nation's Space Program" by representatives of the three services, Department of Defense, NASA and ARPA.

Samuel K. Hoffman, vice president of **North American Aviation Inc.** and general manager of **Rocketdyne,** will receive the Robert H. Goddard Memorial Award at the Wednesday night dinner. Other top awards: C. N. Hickman Award, Dr. Ernest Roberts, **Aerojet-General,** Azusa, Calif.; G. Edward Pendray Award, Ali Bulent Cambel, Northwestern University; ARS Astronautics Award, Dr. Walter Dornberger, **Bell Aircraft;** James H. Wyld Memorial Award, Karel J. Bossart, **Convair.**

In addition, 21 persons will be awarded Fellow memberships in the ARS. They are:

Kurt R. Stehling, NASA, Washington; Raemer E. Schreiber, Los Alamos Scientific Laboratory; Milton Rosen, NASA, Washington; Eberhard F. M. Rees, Army Ballistic Missile Agency, Huntsville, Ala.; Walter T. Olson, NASA, Cleveland; Lester Lees, **Guggenheim Aeronautical Laboratory, Cal Tech;** Kurt H. Debus, ABMA; John I. Shafer, JPL; William Avery **Applied Physics Laboratory,** Johns Hopkins University; Maj. Gen. Leighton I. Davis, Air Force, Washington.

Also, Thomas F. Morrow, **Chrysyler Corp.;** Homer J. Stewart, NASA, Washington; James Van Allen, State University of Iowa; William G. Purdy, **Martin Co.,** Denver; T. Keith Glennan, NASA, Washington; Richard D. Geckler, Aerojet-General, Sacramento; Adolph L. Antonio, Aerojet-General, Azusa; David A. Young, Aerojet-General, Monterey; Kurt Berman, **General Electric Co.,** Ballston Spa, N. Y.; Robert M. Lawrence, **Thiokol Chemical Co.,** Bristol, Pa.; James J. Harford, ARS, New York.

More than 100 technical papers will be given at 24 unclassified and five classified sessions. Here are the times and subjects of the unclassified sections:

- **Monday, 9 a. m.**—Guidance, Physics of the Atmosphere and Space, Wave Phenomena.
- **Monday, 10 a. m.**—Section Delegates Conference.
- **Monday, 2:30 p. m.**—Ion Propulsion, Bio-Instrumentation in Space Research Vehicles, Propellants and Combustion.
- **Monday, 4 p. m.**—Annual ARS business meeting.
- **Monday, 8 p. m.**—Man in Space—Design Work to Date.
- **Tuesday, 9 a. m.**—Safety and Reliability of Liquid Rockets, Astrodynamics, Far Space Communications Techniques, Space Law & Sociology.
- **Tuesday, 2:30 p. m.**—Solid Rocket Technology, Space Communications Equipment, Philosophy of Education—the Scientist and Engineer and Their Environment.
- **Tuesday, 3:30 p. m.**—Marketing Symposium.
- **Wednesday, 9 a. m.**—Structures and Materials in Near Space Current Problems of Space Travel, Test Facilities and Ground Support Equipment, Advances in Miniaturization, Louis B. Forman, Chrysler Corp.
- **Wednesday, 2:30 p. m.**—Plasma Propulsion, Recoverable Booster, Payload Instrumentation.
- **Thursday, 9 a. m.**—Space Law & Sociology, Power Systems.
- **Thursday, 2:30 p. m.**—Power Systems.

These classified sessions are scheduled: Tuesday, 2:30 p. m., Ramjets (confidential); Wednesday, 9:30 a.m., Survey of Storable Propellants and Combustion Oscillations (confidential); Wednesday, 2:30 p. m., Liquid Rockets (confidential); Thursday, 9:30 a. m. and 2:30 p. m., Recent Advances in Nuclear Propulsion (secret — restricted data).

IRE Group Told of High Reliability of M-I-S

BALTIMORE—A manned space system would be about four times more reliable per pound of weight than an unmanned system, according to **Martin Co.** engineers.

Speaking here before the sixth annual IRE Aeronautical and Navigational Electronics Conference, R. D. Sorkin and M. A. Grodsky, Martin-Baltimore, said that, for a reliability of .999+, a manned system would require about 32% additional weight while a comparable unmanned single back-up system would need 200% additional weight, and a double back-up 360%.

Other conference papers applicable to missiles and space travel covered satellite tracking, electronic space suit instrumentation, and electronic maintenance in space. Classified sessions were devoted to advanced radar techniques and equipment.

'Made by the Bay for the U.S.A.'

Southern California has more large firms in missile industry, but San Francisco area grows in popularity as site for all phases of Space Age manufacture

by Frank G. McGuire

SAN FRANCISCO—The San Francisco Bay area doesn't match Southern California in sheer multitude of large manufacturing firms (see M/R Sept. 7 & 28). But it encompasses a tremendous missile/space effort by industrial, research and electronics companies, as well as universities.

Giants in the area—**Lockheed, Westinghouse, Stanford Research Institute** and others—are supplemented by many small, specialized firms. The dominant field is electronics, represented by **Hewlett-Packard, Eitel-McCullough, Varian Associates, Sylvania, Sierra Electronics, Ampex Corp., Dalmotor, Beckman & Whitley,** and dozens of smaller manufacturers. The gamut runs from raw materials suppliers like **Coast Manufacturing and Supply Co.,** to final installation specialists like **Ets-Hokin & Galvan.**

The many-faceted **Food Machinery & Chemical Corp.** has its Ordnance Division in San Jose, turning out missile frames, propulsion systems and various support and handling equipment. Prominent among valve manufacturers is the **Grove Valve & Regulator Co.**

• **Top dog**—Lockheed's Missiles and Space Division participates in more than a dozen major projects and a number of minor ones; it probably is the area's largest employer, with 13,800 on its payroll, and $50 million invested there—not counting a $10-million Navy building housing the *Polaris* program, and a $1-million Air Force building housing its satellite programs.

About 11,870 LMSD's employes are based at the Sunnyvale facility, and 1100 at Palo Alto, with most of the remainder scattered throughout a number of leased offices. The Santa Cruz test site, a 4000-acre facility, utilizes 484 persons and two test stands for ground testing various systems and components.

Some idea of the scope of LMSD may be gleaned from the fact that its 1958 sales—$302,178,000—constituted 31% of Lockheed's total, while 1959 sales are expected to approximate $375 million. The weekly payroll in the Bay area alone is about $1.5 million.

A 346,000-square foot building to house all of the division's three ad-

SPRAWLING OVER 645 acres, Lockheed Missiles and Space Division's Sunnyvale site includes recently activated headquarters for *Discoverer, Midas* and *Samos* projects.

TEST OF *Polaris* launcher, made by Westinghouse's Sunnyvale Division.

vanced satellite projects (*Discoverer, Midas* and *Samos*) was completed at Sunnyvale and occupied in September. The $8-million structure is used by 2500 scientists, engineers, technicians and support personnel in the three programs.

The division's Space Communications Laboratory was doubled in size in August, with completion of an 8000-square foot addition. The lab is studying satellite communication, radio astronomy and other systems through use of advanced techniques including MASERS.

In addition to current work on *Polaris, Discoverer, Midas* and *Samos*, the division's Bay area facilities have carried out work on the *X-7* and *Kingfisher* projects, as well as continuing research on nuclear physics and other basic fields.

- *Polaris* **launchers**—Westinghouse Electric Corporation has some 3500 employees in the Bay area, most of them at its Sunnyvale Manufacturing Division, which makes the launchers and handling equipment for *Polaris*-packing submarines like the USS Theodore Roosevelt recently shown for the first time at the Navy's Mare Island Shipyard.

("Made by the Bay for the U.S.A." was considered as a label for the launching of the Roosevelt and its full-scale model *Polaris*, since the shipyard built the sub, Lockheed-Sunnyvale was prime for the missile, Aerojet-Sacramento [not far from the Bay] supplies *Polaris*' propellant, and Westinghouse makes the submarine nuclear reactor.)

It's impossible to estimate the sales volume of Westinghouse's Sunnyvale Manufacturing Division, since the parent corporation does not break down its sales reports by division.

- **Research reservoir**—Stanford Research Institute, an almost-bottomless source of research in a great number of fields, has also acted as mother-hen to several commercial enterprises founded by its "alumni."

Founded in 1946 to provide a fountain of applied research for the Western states, SRI has since made its mark in many fields, including electronics, solid and liquid rocket propellants, economics, transportation, explosives, medicine, and almost any other field you care to mention.

Employing over 800 full-time professional scientists at Menlo Park, the institute has four research divisions: Engineering, Physical Sciences, Economics, and Poulter Laboratories. The first of these, Engineering, has made considerable gains in microwave, data processing, control systems, and other fields. The Economics Division has concentrated its efforts in four areas: area development programs, concerned with studies of specific geographical areas; industrial economics, concerning long-range planning & marketing; defense research, including civil defense, logistics, etc.; and management sciences, including industrial operations research and computer-applications studies.

Physical Sciences Division is self-explanatory, delving into chemistry, physics, chemical physics, metallurgy and biology. Areas researched are numerous and cover ion exchange, fluid flow, heat transfer, solar-energy utilization, cermets, among others.

One of the latest additions to the Poulter Laboratories Division is the Propulsion Laboratory. The Poulter Lab is primarily concerned with work on explosives and detonation processes. Studies are also carried on in combustion research and high-pressure phenomena. The new Propulsion Laboratory will deal with high-energy propellants for large rocket engines. Its lab and test facility covering 16,000 square feet and using the most modern equipment, is at the Calaveras test site near San Jose.

An indication of the reputation enjoyed by SRI is seen in the extent to which major companies turn vital projects over to the institute with complete confidence.

Sylvania Electric Products Company, early in the 1950's, was searching for a western plant location. Sylvania chose a site in Mountain View from among a number of sites suggested by SRI. The SRI Engineering Division then assisted in developing a new product for the new plant. It then developed a pilot production line for the new product, hired the nucleus of a production staff in Sylvania's name, and provided training for the staff which was transferred to the new plant to manufacture the new product.

Varian Associates, located in Palo Alto, has doubled its master plan for construction in the Stanford Industrial Park from 500,000 to 1,000,000 square feet. The site is a 65-acre plot in the industrial park, and it is estimated that by the end of 1960, Varian's Palo Alto facilities will total 500,000 square feet.

Included in the master plan are an addition to the instrument building, a new unit added to the tube research and development facility, a radiation division building, and administration building, and support buildings.

Originally organized as a research company, Varian branched out into manufacturing, and became a dominating force in the production of klystrons and other microwave tubes, electron linear accelerators, spectroscopy instruments and vacuum products. Employees now number 2700 and company assets total about $24 million. Sales backlog for Varian and its associated companies totals $20, with an expected 1959 sales volume of $38 million. A 50% increase in earnings over 1958 is also anticipated.

Pyromet Company, specialists in brazing and heat treating, have begun construction of a $250,000 production facility in San Carlos. The site is ex-

TWO TEST stands tower over LMSD's Santa Cruz site, with the Pacific Ocean in the background. The site covers 4000 acres and has a payroll of some 484 persons.

A host of electronics manufacturers . . .

pected to be ready for occupancy early in 1960. The nine-year-old firm is building the plant as part of an overall program to take advantage of expanded business volume.

Special production equipment housed in the new plant will be a bell furnace with six-foot-diameter working area for dry hydrogen brazing, along with a company-developed high-vacuum furnace. An expanded R & D capability will be housed in a metallurgical laboratory included in the plant.

Huggins Laboratories, Inc., manufacturers of travelling wave tubes for microwave applications, is one of those small companies whose staff and business volume practically double each year. Located in Sunnyvale Development Center in a plant designed to house 400 employes in its 30,000 square feet, the firm began in 1952 with one employe, and the number has doubled each year since.

Ultek Corporation, a recently-formed organization for the development and production of electronic vacuum pumps and related equipment, has as its president a former research engineer from Varian, Lewis D. Hall.

Eitel-McCullough, producers of over 100 vacuum tube types, has two of its three plants in the Bay area, the other one being in Salt Lake City. The most modern of the three, in San Carlos, was completed in 1958, and gives the firm 150,000 square feet of working space. Eimac's third plant is in San Bruno. Much of the company's production utilizes the Eimac-developed ceramic-metal design in tube construction.

Sierra Electronic Corp., a division of **Philco Corporation,** has facilities at Menlo Park for the production of electronic test instruments and systems and related equipment. Included in Sierra's line are signal generators, calorimeters, transistor testers and oscilloscopes.

Hewlett-Packard, the world's largest manufacturer of measuring instruments, employs over 2000 persons in the Bay area, and has an annual payroll of about $13 million. Sales have moved from the 1950 figure of $2.3 million, to the present level of $40 million annually.

The firm's production facilities consist of two plants in the bay area, one in Palo Alto and the other in Palo Alto's Stanford Industrial Park. Two new buildings are being added to the industrial park site. Upon completion of these, the company will have a total of 570,000 square feet of factory area. HP is also commencing operation of a small plant near Stuttgart, Germany, and has recently established a subsidiary marketing organization in Geneva, Switzerland.

HEWLETT-PACKARD is representative of electronics activity in the Bay area, employs 2000. Here new voltmeters are assembled for testing at HP's Stanford plant.

HP has recently acquired **Palo Alto Engineering Company** and **Dymec, Inc.,** of Palo Alto, as well as **Boonton Radio Corp.** of Boonton, New Jersey. The latter, with annual sales of $2.5 million, will be operated as a separate company.

Caswell Electronics Corp., a San Jose firm, has work underway in microwave research, and in production of waveguide, ferrite and coaxial components. The company has recently suggested a new method for scanning microwave antennas, involving an electronic system which applies a longitudinal magnetic field to a waveguide slot partially loaded with ferrite. This scans the transmitting and receiving beam patterns radiated by the aperture.

American Ordnance Technician Services, Inc. has recently been formed to extend and broaden the services of **Western Ordnance Repair Co.** The firm specializes in servicing ordnance systems for prime contractors who need technical assistance on short notice. AOTS handles installation, test, acceptance checkout, maintenance, repair and overhaul. The 95-man company specializes in handling complex weapon-systems ranging from the German *V-2* to the *Sidewinder, Sparrow,* vintage, and other weapons now in development.

Latest Univac Computer Is 200 Times Faster

NEW YORK—A new computer, designed with the help of another computer, can operate at speeds 200 times faster than any similar equipment in use today.

The new system, just announced as available, is the Univac Larc Solid-State Computer, a large-scale digital computing system originally designed and constructed by **Remington Rand's Univac Division** for the Atomic Energy Commission for use at Livermore, Calif.

The Larc is geared to handle a range of variables extending from missile tracking to preparation of company payrolls. It can perform 250,000 additions or subtractions of 12-digit decimal numbers per second.

Data processing and scientific problems can be performed concurrently by the $6-million machine.

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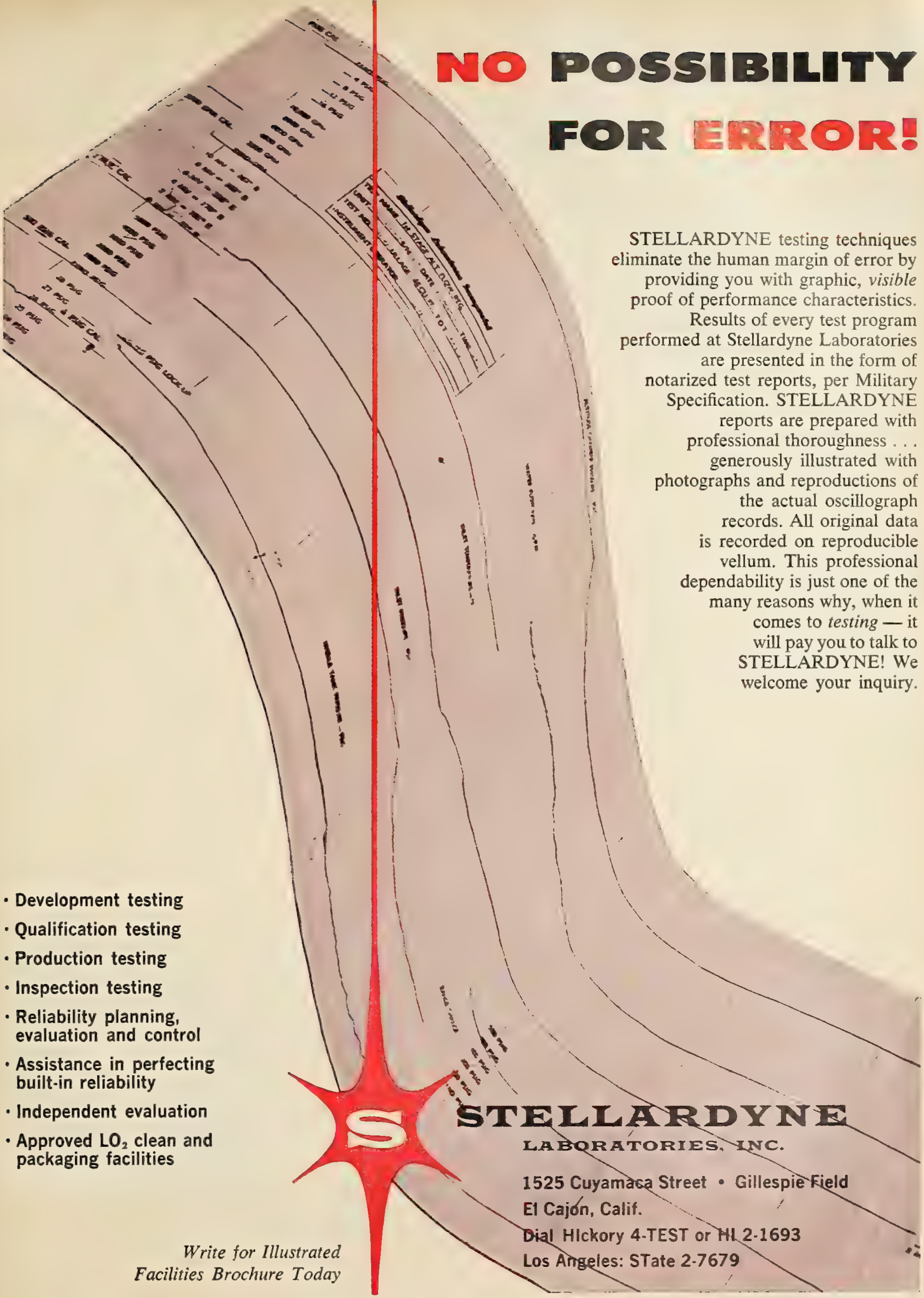

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Reliable Cooling: A Major Problem Is Being Solved by the Infrared Industry

IR-detector cells are behind state-of-the-art of cells, but current R&D efforts are closing the gap with better hardware, advanced methods

by Charles D. LaFond

WASHINGTON—Among the many technical problems facing the infrared industry today, one stands out on each list of trouble areas—the cooling of IR detector cells. Almost every company involved either is researching on its own to develop better coolers or has subcontracted the job to a company specializing in this type of component refrigeration.

To obtain the very best possible operating characteristics from long wavelength IR detectors, they must be cooled. Some require cooling down to liquid nitrogen temperatures (–196°C), but others operate best at temperatures well below this point.

In the laboratory, the problem is a relatively small one; by the use of liquid neon, hydrogen, or helium, temperatures as low as –268.9°C can be reached. But such gases are not readily available—and they are very expensive. The real problem must be faced when we attempt to put such systems in missiles, satellites, and aircraft detection systems.

Briefly, there are five principal problem areas: reliability, weight and volume, contamination of gases, power requirements and hardware costs. Industry is vigorously investigating all of these areas. There are some associated problems which will have to be solved when the major troubles are conquered. Accessibility is certainly an obstacle: the detector assembly may be completely within the particular infrared system, and this in turn may be inside the vehicle. Cooling time is another roadblock; it may vary from a few minutes to several days without allowing the recharging of the refrigerant.

Furthermore the environment and attitude of the vehicle must be considered. Any cooling system used in a missile/space vehicle must be capable of high performance at any altitude, temperature or position that the craft may assume. Finally, the detector assembly may be in gimbals which must not be unduly encumbered.

The views of **HRB-Singer, Inc.,** probably best indicate a typical customer attitude toward future cooling system needs. This firm believes that the great need is for a reliable closed-loop cooling system, with the stress on the word reliable. It feels that the big problem in this area is one of keeping the gas contaminant-free. Foreign matter introduced at the pumping stage is not always filtered out, systems foul up, and many man hours are lost as a result. Present-day cooling systems are far behind the state-of-the-art of detector cells.

The company is now using liquid-nitrogen systems because they are reasonably reliable. When used beyond the atmosphere, however, liquid nitrogen will no longer be adequate. Thus the need for a closed-loop system for use in a missile or space vehicle becomes doubly important.

The company has found that liquid nitrogen is hard to handle, and remains effective for a limited time. In summary, then, the company wants a lightweight, reliable, trouble-free, closed-loop system that will go lower than liquid nitrogen, and be free of the troubles associated with liquid nitrogen.

- **Types of systems**—There are many different systems, but they fall essentially into four principal groups: expansion, cryostat, direct liquid transport, and thermoelectric systems.

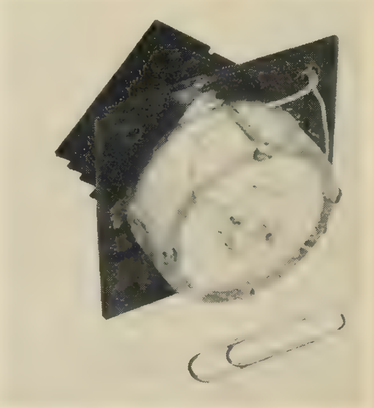
The cryostats use nitrogen, and there are three general types. One uses stored, compressed gas; another employs a liquid nitrogen converter; a third uses a compressor in a closed loop.

The expansion engines employ liquid helium and there is another system employing a gas liquifier with helium. There also have been developed cryostats for use at somewhat higher temperatures, employing carbon dioxide or Freon 13.

The Peltier-thermoelectric coolers currently are arousing a great deal of industry enthusiasm. This is for one principal reason—they have excellent reliability, and they are lightweight. The principal problem is to increase the temperature-differential. At present, most of the single-stage Peltier coolers have a temperature-difference range of from 40° to 50°C from an ambient of 25°C. Power requirements for the Peltier-type coolers are very low—approximately 2½ watts.

The miniature cryostats were the first major approach to cooling long-wavelength detectors. Essentially they consist of a short length of thin metal tubing of small size wound about a mandrel. This unit is installed in a close-fitting tube comprising the inner portion of a small vacuum flask.

Pressurized nitrogen gas is directed through the tubing toward the back of



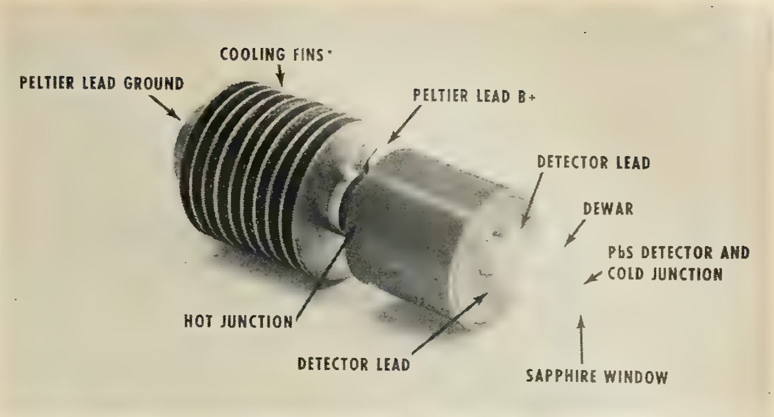
AN INFRARED detector-cell cooling unit with a finned heat sink developed by the Philco Corporation. The company is pushing a search for better materials.

the detector. As the gas emerges, it is cooled by Joule-Thomson expansion. The gas, following expansion, is directed back over the coil of the tubing, producing regenerative cooling. Eventually, the gas is cooled enough to liquify at a temperature close to −196°C.

In the liquid nitrogen converter system, gas is stored in liquid form in a pressure vessel. By means of forced evaporation, high-pressure gas of very high purity is produced because the contaminants are frozen out in the liquid-nitrogen state.

Another method of operating a cryostat is by means of a closed-loop unit employing a non-contaminating compressor. So far, piston-type compressors have been generally unsuccessful, but bellows and diaphragm type compressors are well along in development by several companies.

The direct liquid nitrogen transfer system was mentioned earlier. In this technique an insulated flask stores the liquid nitrogen and maintains a small pressure, usually less than 15 psig. Liquid nitrogen is forced by the pressure through a tube which transports the liquid to the area of the detector. At this point two methods of application may be used: the liquid nitrogen may be passed into a heat-exchanger at the detector and thus leave the system in an expanded gaseous state; or droplets of liquid nitrogen may be sprayed on the rear of the detector.



PELTIER-TYPE IR cell cooler draws 20 amperes at 0.1 volt to produce temperature differential of 50°C at room ambient. Peltier design is by Nortronics; package by Infrared Industries. Fins may be omitted if adequate heat sink is available.

The expansion engine normally is used for the liquefaction of helium. Gas is compressed which causes it to lose energy in expansion by doing work and thus its temperature is reduced. Additional Joule-Thomson expansion causes liquefaction. The gas liquefier uses an expansion engine to cool an enclosed surface. When the gases come in contact with this surface they are cooled, condensed and then flow off as a liquid. The systems eventually will be recirculating and will operate on a single charge of coolant gas.

• **Recent results**—Because of the large number of companies involved in cooling research for detector cells, we cannot hope to cover all of their recent advances. But we can cover what a few of the major companies have been doing in the past few months and describe some of their results.

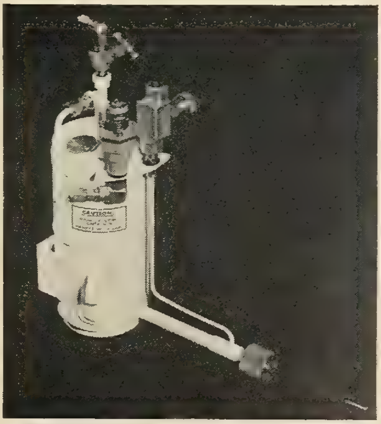
The **Linde Co.**, a division of **Union Carbide,** has been working with four types of liquid nitrogen systems. It also has a research program in progress for liquid-helium-cooled dewars, but according to a company spokesman this is in the early stages of research and its studies are devoted primarily to the feasibility of systems of this type.

Liquid feed-vacuum insulated supply line with an insulated vessel is used by Linde for situations where the dewar must be located at some distance from the cell to be cooled. The system has an evaporation rate lower than the use rate, thus the same container might be capable of 24-hour standby and 8-hour operation, or 48-hour standby and 5-hour operation. An increase in standby time does not result in a corresponding decrease in operating time, as can occur in other basic systems.

Vacuum insulated lines have been furnished straight or coiled to reduce vibration effects. Linde currently is working on flexible vacuum insulator lines to accommodate scanning detectors. But this is still in development stage. The company feels that the liquid-vacuum insulated line systems are the most versatile of the four types of nitrogen cooling systems.

Linde also is working with bare liquid feed line systems, but here the line conducts more heat to the liquid

A RECENT development by the Linde Company is this 3 in. diameter X 4 in. integrally mounted cell and liquid N_2 cooler, having 8.5 hours holding time.



ANOTHER NEW Linde product is this liquid N_2 feed-vacuum insulated line. The unit has a 24-hour standby time and a six-hour operating time.

PROTOTYPE OF a Westinghouse diaphragm compressor for supplying high pressure nitrogen gas to a cryostat. Diaphragm is free floating.

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than the insulator type, resulting in a higher use rate of liquid. This higher use rate partly is compensated for by lower cost, sturdier construction of the feed line and easier maintenance.

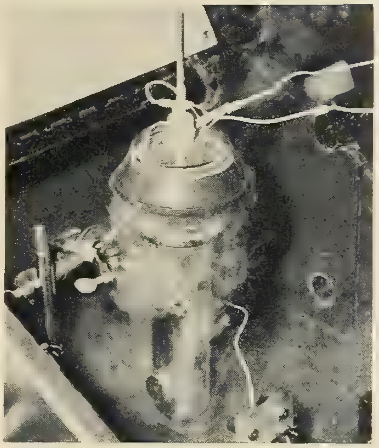
In the company's high pressure liquid-to-gas generators, the systems may or may not have insulated vessels. The insulated vessels provide much longer standby periods without the loss of gas. The company feels that this type of system is inferior to the liquid feed systems for cooling IR cells. To meet pressure requirements necessitates large containers. Another great disadvantage to this high pressure system is the susceptibility of cryostats to clogging due to ice formed from moisture and other impurities in the gas.

If the situation demands the use of a cryostat, the gas generator is then more desirable in the storage of high pressure nitrogen. One pound of liquid requires one/third the volume needed to store one pound of gas at 3500 psia.

The simplest system with which Linde has been working is the integrally-mounted cell. The detector cell is mounted on a conductor such as a sapphire rod or metal button which is in direct contact with the inner shell of the dewar. To fill, liquid is poured into the container and the cell is cooled during the fill. The use rate is the same during standby or operating condition because the cell is always cold. In general, systems with cells mounted in the vacuum space and close to the inner vessel shaped to give the minimum outside area for a given capacity will yield the highest holding times.

The **Santa Barbara Research Center,** a subsidiary of **Hughes Aircraft Co.,** has developed several systems for automatic operation in airborne environments. The two most satisfactory systems according to the company, are Joule-Thomson coolers operated on demand by a liquid level censor, and pressure-regulated liquid transfer systems using uninsulated transfer tubing. (See M/R Sept. 28.)

The Research Center also has found that detectivity is limited by ambient or room temperature radiation falling on the detector cells. The idea of course, is not new, but the company believes that it had not been demonstrated previously with lead selenide. By providing appropriate shielding in the detector package, improvements in detectivity of a factor of from 6 to 10 have been achieved. Shielding is designed to fit the optical system (improvement in detectivity is inversely proportional to the sine of ½ the angle subtended by the aperture of the detector.) The improvement is attained by an increase in the signal-to-noise level so that the shielded detectors are easier to use with conventional amplifiers.



LAB MODEL of Santa Barbara Research Center's Joule-Thomson hydrogen expansion system. Dewar operates below liquid H_2 temperatures.

Another technique employed by SBRC involves the restriction of the amount of ambient radiation by using spectral filtering. Selective filters on the detectors absorb light of wavelengths not contained in the signal radiation.

A typical liquid transfer unit developed by SBRC weighs 7.5 lbs. complete when filled with liquid nitrogen. The company said it can cool a complicated 8-detector package for more than 6 hours under in-flight conditions and after a standby time of 24 hours.

Westinghouse Electric Corporation, Air Arm Division, has done extensive work in closed-loop infrared detector cooling systems. The company has been working to improve the reliability factor for both short and long-term operating periods.

Westinghouse chose for its specific system development a diaphragm-type contaminant-free compressor supplying high-pressure nitrogen gas to a Joule-Thomson regenerative cryostat. The latter, the company believes, offers two basic advantages over an expansion-type cryostat. The first, is the lack of any moving parts in the cryostat at low temperature. The second is the absence of a temperature regulating device in the cryostat to compensate for heat-load variations.

The closed-system arrangement developed by Westinghouse has been tested for a period of over 500 hours at a cryostat tip temperature of −175°C. Only minor difficulties have been encountered to date. Heart of this system is the compressor. A series of O-rings within the compressor prevents contamination of the gas from the hydraulic system.

A critical component of the compressor was the diaphragm itself. Compressors of this type with metallic diaghragms have been used successfully for some time in gas purification systems. However, due to miniaturization required for missile and aircraft application, design of the cavity was extremely critical from a displacement point of view in order to meet the flow rate requirements of the closed system.

Two diaphragm materials were chosen for test purposes. One a stainless steel, the other a titanium alloy. Both materials proved to possess the proper combination of ductility and high endurance limit.

It may also be noted that in this particular design the diaphragms are free floating, not clamped around the edges. The design has proven entirely satisfactory under tests, according to the company, indicating that the life of the diaphragms will not be exceeded during the normal life of the compressor.

The company also has been working with an extension of this design concept to use a combination nitrogen-neon system. This may result in an airborne system capable of cooling detector cells to a temperature of −233° to −243°C.

The Garrett Corporation's Air Research Manufacturing Division has developed highly successful cryostats employing nitrogen gas and also employing liquid nitrogen for direct transfer (see M/R Feb. 16). Also the Min-Ircooler developed by **Arthur D. Little** has gained considerable publicity because of its very small size. The 8-ounce unit employs helium gas and can drop the temperature of an IR cell to 60°K. Total system weight eventually will be less than 10 pounds, according to the company (see M/R, May 25).

The Philco Corp. has for some time carried out a company-supported research program for cryogenic cooling of IR detector cells. Much of its current research dollar in this area is going toward advanced forms of thermoelectric cooling. The Philco infrared cell cooling unit employs a finned heatsink and using Peltier effect, has achieved a temperature differential of approximately 40°C. Current requirements are approx. 12 amps.

The company feels that material barriers have been pushed to their limit at the present time. Thus its researchers are extending their efforts to find materials with lower thermoconductivity, higher electrical conductivity and higher thermoelectric power.

Many, of course, believe that Peltier-type refrigerators may be the best solution to the detector cell cooling problem. It has one great advantage in that it can be constructed integrally with the detector itself. It has no moving parts, and can be highly reliable.

Infrared Industries, Inc., believes that it has developed the first Peltier cooler in a practical package. Working with **Nortronics Division** of **Northrop Corporation** for the past year, a highly successful device has been developed. It draws 20 amps at 0.1 volt and produces a temperature change of approximately 50°C at room temperature with a single-stage unit. It can achieve 50% more cooling with a 2-stage version of the same device. Besides the advantages of the Peltier cooler, already mentioned, Infrared Industries believes that it has several other very important attributes, particularly for missile and space environments: 1) A vacuum and most other environments have no direct effect on performance. 2) the efficiency improves as the reference junction temperatures goes up. This tends to compensate for any design error realized in maintaining temperature of the heat sink. 3) While a power supply for the cooler is required, it may be located at almost any remote location.

Working with the **Walter Kidde Co.,** Infrared Industries has also produced a very low cost carbon-dioxide cooler employing a simple 0.3 oz. "Sparklet" type cartridge. An IR cell can be cooled to approximately dry-ice temperatures, (–78°C) for approximately one hour. Cool down time is of the order of a minute or two, but this can be speeded up to a few seconds at the sacrifice of cooling duration. The depressed temperature can be maintained indefinitely by the replacement of the spent cartridge every hour or so. Also the same cryostat and filter can be used with the larger CO_2 bottle and a more complex valve for extending duration time to about 24 hours. Both of these CO_2 systems are considered ideal for lab use rather than for missile or aircraft applications.

According to a **Nortronics Laboratory** spokesman, its recently developed two-stage units, using improved materials, have yielded Peltier cooling of 79°C from room ambient. The company expects that still better materials will be available in the future providing correspondingly greater cooling for both single and double-stage units.

Explorer VI May Solve Puzzle of Repetitious Radio Signals

Menlo Park, Calif.—The mystery of why radio signals sometimes repeat themselves seconds later may be solved by scientists experimenting with the help of *Explorer VI.*

A theory postulated by Dr. R. A. Helliwell, of Stanford University, is that while most low-frequency waves are reflected back by the ionosphere, some manage to penetrate this barrier and go on out into space. Here they are captured by magnetic field "ducts" which conduct them back to earth again, thousands of miles from the transmitter.

NASA's paddlewheel satellite carries an ultra-sensitive VLF receiver—the first in space—designed to pick up these signals as the ionized ducts are crossed. The signals are then relayed back to earth by telemetering equipment.

Special ground receivers located throughout the world receive, as a reference, the original radio transmissions by the usual paths. After evaluation, the compared data is expected to give clear evidence of the existence and location of the postulated ducts.

The experiment is also expected to shed light on other aspects of radio waves and ionization patterns in space. Detailed levels of the "fall-off" in signal strength from the rocket as it rose from earth through the ionosphere will provide valuable data on the makeup of this ionized layer.

In addition, the satellite receiver will register any VLF signals that may originate in outer space. So, not only will the experiment indicate how much low-frequency noise gets through the ionosphere from below, it will help show something about signals from above that can't penetrate to earth.

IRE Meeting Hears Reports on Myriad Electron Devices

Washington—More than 1300 electronic engineers and specialists jammed the 1959 IRE Electron Devices Meeting here last week.

Invited papers on three most widely discussed subjects in the electronics industry—tunnel diodes, low-noise amplifiers, and multifunctional devices—highlighted the opening. Dr. R. N. Hall, of **General Electric's** Research Laboratory, described the potentialities of the Esaki, or "tunnel," diode which shows great promise for ultrafast switching applications.

Professor H. Heffner, Stanford University, reported on competing device concepts for achieving low noise in solid-state and other electronic amplifiers. Such low-noise performance is vital in improving the range characteristics of communications systems such as radar and radio astronomy.

Dr. I. M. Ross, of **Bell Telephone Labs** presented the third invited paper, on the broad field of multifunctional solid-state devices. Among devices being investigated include micromodules, solid circuits, molecular electronics, and microminiaturization.

Frederick R. Lack, director of EIA and former vice president and director of **Western Electric,** summarized the past and present status of electron tube delevopment in an address at the opening-day luncheon. He warned against the pitfalls of moving too fast in adapting new electronic devices to expanding industries and military markets.

Nine technical sessions covered new designs and increased capabilities of traveling-wave and backward-wave devices, cathode-ray tubes, solid-state devices, and other electronic components.

Among the major advances described were a 220 mc negative resistance parametric amplifier for use in solid-state UHF receivers. The amplifier provides a low-noise figure and stable operation, with gain of 13 db despite pump power of only 0.1 mw. It registers noise figures between 1 and 2 db without a circulator or isolator.

Devices and techniques reported by foreign engineers included a silver-bonded diode for paramps, by engineers of **Nippon Telegraph and Telephone,** Tokyo; a series of pulsed high-perveance high-power klystrons for linear accelerators, by representatives of **Compagnie Génerale de Télégraphie Sans Fil,** Orsay, France; and characteristics of a beam power multiplier tube, by engineers from Cairo University.

ASTROLOG

A status report on U.S. missiles and rockets and all space vehicles presently in orbit

★ Indicates change since Sept. 7 edition

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
SPACE VEHICLES			
★ATLAS-ABLE (NASA)	STL, prime; GE/Burroughs, Arma, guidance; Rocketdyne, Aerojet-General, ABL, propulsion	Orbit 200-lb. vehicle around moon or send into deep space	Moon orbit attempt scheduled for November
CENTAUR (NASA)	Convair, prime; Pratt & Whitney/JPL, propulsion	Soft-land 730-lb. on moon	First test flight in fall, 1961
★COURIER (ARPA-Army)	Army Signal Corps, prime	Delayed repeater communications satellite	R&D; satellite in advanced stage; first to be launched in spring
★DECREE (ARPA)	No contract announced	24-hour instantaneous repeater satellite	R&D
DISCOVERER (ARPA-AF)	Lockheed, prime	Thor-Agena launchings of early stabilized satellites	Of first 6 launched, 3 stabilized in orbit; ejected capsules not recovered
DYNA-SOAR I (Air Force)	Boeing and Martin/Bell, competing	Boost-glide orbital test vehicle	Late study stage
JUPITER-C (NASA)	ABMA/Chrysler, prime; Sperry, guidance; Rocketdyne, JPL, propulsion	Early satellite booster; small payload	Being phased out
★JUNO II (NASA)	ABMA/Chrysler, prime; Ford Instrument, guid.; Rocketdyne/JPL, prop.	Early deep space booster; small payload	Five more shots planned
★MERCURY (NASA)	NASA, prime; McDonnell, capsule	First manned satellite	Capsule testing being conducted; manned capsule launching by REDSTONE down Atlantic
MIDAS (ARPA-Air Force)	Lockheed, prime	Early-warning satellite; detect ICBM launchings by infrared before birds leave pad	R&D
★MRS. V (ARPA)	No contract announced	Manueverable, recoverable space vehicle; also known as DYNA-SOAR II	Studies; future of project in doubt
NOVA (NASA)	Rocketdyne, prime; Rocketdyne, propulsion	Clustered 6 million lb. booster	Early R&D on 1.5 million lb. engines
ORION (ARPA-Air Force)	General Atomic	Space station launched by series of atomic explosions	Feasibility studies under way; tests may be attempted
★SAMOS (ARPA-Air Force)	Lockheed, prime	Reconnaissance satellite; formerly Sentry	R&D; stabilization already achieved in DISCOVERER series; first test launching scheduled in March
★SATURN (ARPA-Army)	Army Ordnance Missile Command, prime; Convair/Pratt & Whitney, propulsion; To be transferred to NASA if Congress approves	Clustered 1.5 million lb. thrust booster; liquid TITAN second stage; CENTAUR third stage; second stage may be changed by NASA	Timetable in doubt. Under current schedule, 3-stage SATURN would be first launched late 1963 earliest; under crash program, late 1962.
SCOUT (NASA)	Chance Vought, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Allegany/Thiokol, propulsion	Four-stage satellite launcher; 200-300 lb. payload in orbit	Operational next spring
★STEER (ARPA)	GE-Bendix, prime	Polar-orbiting instantaneous repeater satellite	R&D
★SUZANO (ARPA)	No contract announced	Space platform to be used as base for staging and other missions	Feasibility studies; no funding

This Astrolog May Be Detached from the Magazine for Constant Reference

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★THOR-ABLE (NASA)	STL, prime; Rocketdyne/Aerojet-General/ABL, propulsion	Early deep space booster	Sun orbit shot in late November
THOR-DELTA (NASA)	STL, prime; IT&T, guidance; Rocketdyne/Aerojet-General/Allegany,prop.	Put 65-lb. satellite in orbit around moon	R&D; first flight early 1960
★TIROS (NASA-Navy)	RCA-Army Signal Corps, prime	Meteorological satellite; TV pictures of cloud cover	R&D; first test launching 1960
★TRANSIT (ARPA-Navy)	Lockheed and Johns Hopkins Laboratory, prime	Navigational satellite	First shot almost complete failure because final stage didn't operate; next shot in late winter
TRIBE (ARPA)		Family of space launching vehicles	Planning
VANGUARD (NASA)	Martin, prime; Minneapolis-Honeywell, guidance; GE, Aerojet, ABL, Grand Central, Atlantic Research, Thiokol, propulsion	First planned satellite booster; small payloads	Program ended with successful launching of VANGUARD III September 18
VEGA (NASA)	JPL/Convair, prime; GE, guidance; Rocketdyne/JPL/GE, propulsion	Advanced space vehicle with ATLAS; second stage start-restart; can put 980 lbs. around moon	First flight in fall, 1960
★X-15 (NASA-AF-Navy)	North American prime; Thiokol, prop.	Rocket plane; 3600 mph; flight at edge of space	First powered flight successful
MISSILES & ROCKETS			
ABLE (Navy)	Avco, prime	ASW surface-to-underwater; 500 lb. solid; conventional	Deployed on destroyer escorts
★ASROC (Navy)	Minneapolis-Honeywell, prime	Surface-to-underwater; solid rocket torpedo; nuclear	R&D; operational Jan. 1961
ASTOR (Navy)	Westinghouse, prime	ASW underwater to underwater; rocket torpedo; nuclear	R&D
★ATLAS (Air Force)	Convair, prime; GE/Burroughs, ARMA, guidance; Rocketdyne, propulsion	ICBM; more than 5500-mile range; liquid; nuclear	35 launchings of test vehicles all types: 19 successes, 8 partial; 8 failures; expected operational this month
★AUTOMET (Army)	No contract announced	New solid tactical missile	R&D; test vehicle stage
★ALBM (Air Force)	Douglas, prime; Nortronics, guidance; Aerojet, propulsion	Air launched ballistic missile; more than 1000-mile range; solid; nuclear	Design study
ARM	No contract announced	Anti-radar missile	R&D
★BOMARC-A (Air Force)	Boeing, prime; Westinghouse; guidance; Marquardt, propulsion	Air-breathing surface-to-air interceptor; liquid; 200 m. range; Mach 2.7; nuclear	A model operational at McGuire AFB, N.J.
★BOMARC-B (Air Force)	Boeing, prime; Westinghouse, guidance; Thiokol, propulsion	Air-breathing; surface-to-air; Mach 2.7; more than 500 m. range; nuclear	Late development
★BULLPUP (Navy)	Martin, prime; Republic, guidance; Thiokol, propulsion	Air-to-surface; 4-mile range; conventional 250-lb. bomb	Deployed with Atlantic and Pacific Fleets; bigger model under R&D; Air Force buying modified version
★COBRA (Navy)	No contract announced	Anti-ship radar missile	Early R&D
CORPORAL (Army)	Firestone, prime; Gilfillan, guidance; Ryan, propulsion	Surface-to-surface; 75-mile range; liquid; nuclear	Deployed with U.S. & NATO troops in Europe
CORVUS (Navy)	Temco, prime; Texas Instrument, guidance; Reaction Motors, propulsion	Air-to-surface; pre-packaged liquid; radar homing; about 100-miles range	First successful test July 18, 1959
CLAYMORE (Army)	No contract announced	Anti-personnel missile	R&D
DAVY CROCKETT (Army)	In-House Project at Rock Island, Ill., arsenal	Surface-to-surface; solid; bazooka launched; sub-kiloton nuclear warhead	R&D
EAGLE (Navy)	Bendix, prime; Sanders, guidance	Air-to-air; 100-mile range; nuclear; for launching from relatively-slow aircraft	Early R&D
★FALCON (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion	Air-to-air; 5-mile range; Mach 2; solid; conventional	GAR-1D & GAR-2A & GAR-3 operational; GAR-4 & GAR-9 under R&D; GAR-9 work slowed
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air; unguided; 1.5-mile range; nuclear	Operational
GIMLET (Navy)	No contract announced	Air-to-surface; unguided; considered highly accurate	R&D

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
HAWK (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 20-mile range; solid; conventional; designed to hit low-flying planes	Operational; units training for early deployment
HONEST JOHN (Army)	Douglas, prime; Hercules, propulsion	Surface-to-surface; unguided; 16.5-miles range; nuclear	Operational; deployed in Europe
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Air-breathing air-to-surface; 500-mile range; Mach 1.7; turbojet; nuclear	Nearly operational; to be launched from B-52G intercontinental bombers
★JUPITER (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	IRBM; liquid; nuclear	To be deployed with Italian troops in Italy and Turkish troops in Turkey; 23 launchings: 16 successes; 5 partials; 2 failures
★LACROSSE (Army)	Martin, prime; Federal Telecommunications Laboratories, guidance; Thiokol, propulsion	Surface-to-surface; highly mobile; 20-mile range; solid; nuclear	Operational; 4 units being trained; 3 more planned for 1960
LITTLE JOHN (Army)	Emerson Electric, prime; ABL, propulsion	Surface-to-surface; unguided; 10-mile range; solid; nuclear	Nearly operational; units training with it
LOBBER (Army)	No contract announced	Surface-to-surface; cargo carrier; 10-15 mile range; also can drop napalm	Studies
LULU (Navy)	No contract announced	Surface-to-surface; nuclear	R&D
MACE (Air Force)	Martin, prime; AC Spark Plug, guidance; Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet & solid; nuclear; B model has 1000-m. range	Being deployed with U.S. troops in West Germany
MATADOR (Air Force)	Martin, prime; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 650-mile range	Being turned over to West Germans; also deployed in Far East
MAULER (Army)	No contract announced	Surface-to-air; IR guidance; field weapon	R&D
★MINUTEMAN (Air Force)	Boeing, prime; Autonetics, guidance; Thiokol, propulsion	2nd generation ICBM; solid; mobile; nuclear	R&D. Expected to be operational by late 1962 or early 1963; to be installed in hardened sites and made mobile on trains or trucks
MISSILE A (Army)	No contract announced	Surface-to-surface; 65-70 mile range; solid	Design studies
NIKE-AJAX (Army)	Western Electric, prime; Western Electric, guidance; Hercules Powder, propulsion	Surface-to-air; 25-mile range; Mach 2.5; solid & liquid; conventional	Deployed in U.S., Europe & Far East
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules & Thiokol, propulsion	Surface-to-air; 80-mile range; Mach 3+; nuclear	Rapidly replacing NIKE-AJAX
★NIKE-ZEUS (Army)	Western Electric, prime; Bell Telephone, guidance; Grand Central, propulsion	Anti-missile; 3-stage; 200-mile range; solid; nuclear	R&D; major components being tested; first tests against ICBM's to be in PMR; first launched ZEUS fell apart in flight Aug. 26; second successful but short of programmed range, first and second stages ignited
PERSHING (Army)	Martin, prime; Bendix, guidance; Thiokol, propulsion	Surface-to-surface; solid; 700-mile range; nuclear	R&D; to replace REDSTONE; test launchings imminent at Cape Canaveral
★POLARIS (Navy)	Lockheed, prime; GE, guidance; Aerojet-General, propulsion	Underwater and surface-to-surface; solid; 1500-mile range; nuclear	41 launchings of test vehicle; 28 successes; 11 partial; 2 failures; launched from surface ship Aug. 27, 1959; expected operational late 1960; 900-m. range vehicles under test at Cape Canaveral
RAVEN (Navy)	No contract announced	Air-to-surface; about 500-mile range	Study
REDEYE (Army)	Convair, prime	Surface-to-air; 20-lb. bazooka-type; IR guidance; solid; conventional	R&D
REDSTONE (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; nuclear	Deployed with U.S. troops in Europe
REGULUS (Navy)	Chance Vought, prime; Sperry, guidance; Aerojet-General, propulsion	Surface-to-surface; turbojet & solid; 500-mile range; nuclear	Deployed aboard U.S. submarines
SERGEANT (Army)	JPL/Sperry, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; more than 75-mile range; nuclear	Production. To replace CORPORAL
SHILLELAGH (Army)	Aeronutronics, prime	Surface-to-surface; lightweight; can be vehicle-mounted	R&D; expected to be operational mid-1960's
SIDEWINDER (Navy)	GE-Philco, prime; Avion, guidance; Naval Powder Plant, propulsion	Air-to-air; IR guidance; 6-7-mile range; conventional	Deployment with Naval and Air Force units

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
SLAM (Air Force)	No contract announced	Surface-to-surface; low-altitude; supersonic; nuclear-powered ramjet; nuclear	Study-R&D
SNARK (Air Force)	Norair, prime; Northrop, guidance; Aerojet-General, propulsion	Surface-to-surface; 5500-mile range; solid and turbojet; Mach .9; nuclear	Deployed at Presque Isle, Maine
SPARROW III (Navy)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Air-to-air; 5-8-mile range; Mach 2.5-3; solid; conventional	Operational with carrier aircraft; earlier SPARROW I obsolete
SUBROC (Navy)	Goodyear, prime; Kearfott, guidance; Thiokol, propulsion	Underwater or surface-to-underwater; 25-50 mile range; solid; nuclear	R&D
★SUPER TALOS (Navy)	No contract announced	Seagoing anti-missile missile; possible AICBM	Early R&D
SS-10 (Army)	Nord Aviation, prime	Surface-to-surface; primarily anti-tank; 1600-yards range; 33 lbs. solid; wire guided; conventional	Operational with U.S., French and other NATO and Western units; battle-tested in North Africa
SS-11 (Army)	Nord Aviation, prime	Surface-to-surface; also helicopter-to-surface; 3800-yard range; 63 lbs.; wire guided; conventional	Operational. Under evaluation by Army.
TALOS (Navy)	Bendix, prime; Farnsworth/Sperry, guidance; Bendix/McDonnell, propulsion	Surface-to-surface; 65-mile range; solid & ramjet; Mach 2.5; nuclear	Operational this year aboard cruiser Galveston
TARTAR (Navy)	Convair, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 10-mile range; Mach 2; 15 feet long & 1 foot in diameter; solid dual-thrust motor; conventional	Many test firings in Pacific; expected deployment 1960 as primary armament of guided missile destroyers; production
TERRIER (Navy)	Convair, prime; Reeves/FTL, Sperry, guidance; ABL, propulsion	Surface-to-air; 10-mile range; Mach 2.5; 27 feet long; solid; conventional	Operational with fleet
★THOR (Air Force)	Douglas, prime; AC Spark Plug, guidance; Rocketdyne, propulsion	Surface-to-surface IRBM; 1500-mile range; liquid; nuclear	Operational; 4 bases being set up in England; 50 launchings: 33 successes; 10 partial; 7 failures
TITAN (Air Force)	Martin, prime; Bell, Remington Rand, guidance; Aerojet-General, propulsion	Surface-to-surface ICBM; 5500-mile range; liquid; 90 feet long; nuclear	5 launchings test vehicles: 4 successes; 1 failure; expected to be operational late 1960-early 1961; next launch scheduled in November
WAGTAIL (Air Force)	Minneapolis-Honeywell, prime	Air-to-ground; low-level; solid; designed to climb over hills and trees	R&D
ZUNI (Navy)	Naval Ordnance Test Station, prime	Air-to-air, air-to-surface; solid; unguided rocket; 5-mile range; conventional	Operational

SATELLITES

SATELLITE	COUNTRY	STATUS
EXPLORER I (30.8 lbs.)	U.S.	Launched 1/31/58, est. life 3-5 years. Orbits earth, perigee: 224 m., apogee: 1573 m., period 114.8 min. (Discovered Van Allen Belt)
VANGUARD I (3.25 lbs.)	U.S.	Launched 3/17/58, est. life 200-1000 years. Orbits earth, perigee: 409 m., apogee: 2453 m.
SPUTNIK III (about 3.5 tons)	Russia	Launched 5/15/58, est. life, 15 mo. Orbits earth, perigee: 135 m., apogee: 1167, period: 106 min., inclination to equator: 65.3°. Speed, at perigee: 18,837, at apogee: 14,637 mph.
LUNIK I "MECHTA" (3245 lbs.)	Russia	Launched 1/2/59. Believed to be in orbit around sun on 15 mo. cycle.
VANGUARD II (20.7 lbs.)	U.S.	Launched 2/17/59, est. life 10 years +. Orbits earth but is "wobbling," perigee: 347 m., apogee: 2064, period: 125.85 min., inclination to equator: 32.88°.
PIONEER IV (13.40 lbs.)	U.S.	Launched 3/3/59. Orbits sun, and achieved primary mission, an Earth-Moon trajectory.
EXPLORER VI "PADDLE-WHEEL" (142 lbs.)	U.S.	Launched 8/7/59, est. life 1 year +. Orbits earth, perigee: 156 m., apogee: 26,357 m., period: 12½ hours, speed: at perigee 23,031, at apogee: 3126 mph., inclination to equator: 46.9°.
VANGUARD III (about 100 lbs.)	U.S.	Launched 9/18/59, est. life 30-40 years. Orbits earth, perigee: 319 m., apogee: 2329 m.
LUNIK III (about 614 lbs.)	Russia	Launched 10/4/59, orbits earth-moon; took first picture far side of moon; est. perigee: 30,000 m., apogee: 291,000 m.
EXPLORER VII (91.5 lbs.)	U.S.	Launched 10/13/59, est. life 20 years, orbits earth, perigee: 341, apogee: 679.

Who put the cart before the horsepower?

Autonetics did. Autonetics foresaw that the electronic systems inside a modern weapon would become as important as the frame that enclosed them...foresaw that the twin bugaboos would be time and talent: the time it would take a swarm of skilled technicians with meters and hand probes to make a thorough maintenance test—and the scarcity of such technicians. That's why Autonetics, together with the Department of Defense, set out to automate the whole procedure.

Result: carts that contain today's most versatile automatic checkout systems. These systems match the needs of the majority of manned and unmanned weapon systems. Adaptive equipment for testing special electronic systems can be packaged in similar carts and plugged into the basic cart. The system is thus complete and readily mobile.

Here's the payoff: as part of the Naval Avionics Support System, these new automatic checkout centrals will do the job 100 times as well—and with infinitely greater accuracy. All the operator needs to know is which button to push. This is the reliable way to find fault before you fly.

Automatic checkout centrals by Autonetics

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INERTIAL NAVIGATION / ARMAMENT CONTROL / FLIGHT CONTROL / COMPUTERS AND DATA PROCESSING

Helium Supply Meets Current Needs

But unless steps are soon taken to prevent waste of 3 billion cubic feet annually, the limited supply will be inadequate to meet demands beyond 1980

by David Newman

WASHINGTON—For the first time in a year and a half, helium is being produced fast enough to satisfy the demand for it.

But the Government says that unless legislation now before Congress is enacted, this situation may last only a few years because of the stern laws of supply and demand. No important new sources of helium have been discovered since 1943, and the demand for the unique gas is jumping 20% every year.

Two weeks ago, the Interior Department lifted the informal helium allocation system and notified distributors that there was enough available for essential government and civilian uses. The allocation arrangement had been in effect since April, 1958, when supply and demand lost touch.

The move was made possible by full-speed production of helium at the Government's new Keyes, Okla., plant.

In a relatively short time, however, needs will probably outstrip production. This has been the case sporadically since 1954. In that year, the Interior Department's Bureau of Mines—sole producer of helium—shipped 185 million cubic feet of the gas. In Fiscal 1959, the figure had jumped to 360 million; the five plants now operating will be able to put out about 600 million cubic feet annually.

Even so, a little rough figuring shows that if demand continues to climb at its present rate supplies will run short again by 1962.

• **Long-range answer**—Faced with this potentially critical situation, the Department has taken steps to implement a long-range conservation program. Legislation to amend the Helium Act of 1937 is now before Congress. What the Department wants is authority to build 12 additional plants in the next few years to extract helium from natural gas before the gas is piped to market.

Natural gas is the primary, in fact the sole economical source of helium. (In the atmosphere, it appears in a 1:200,000 ratio.) Ninety-nine percent of the known helim-bearing natural gas resources in the United States is concentrated in four fields, all in the Southwest. These have been developed by private companies to supply natural gas to fuel markets; the helium is piped to the consumer right along with the natural gas—and passed through gas burners into the atmosphere.

Each year three billion cubic feet of helium go up the flue. This is what Interior wants to snare for future use.

A Department study conducted in 1958 indicated that 32 billion cubic feet of the gas could be conserved over the next 15 years, if prompt action is taken to construct the 12 new plants. It showed that these, together with the five plants now in operation, would recover about 43.5 billion cubic feet by 1975. This would be stored at the Government's Cliffside gas field near Amarillo, Tex. More than 32 million cubic feet of helium-bearing gas has been removed from this field since its discovery; consequently, it has the capacity to store an equal amount without exceeding the original field pressure.

Demand between now and 1975 is expected to be about 11.5 billion cubic feet, which would leave the 32 billion for future requirements.

If the bill, now in the House Committee on Interior and Insular Affairs, is eventually passed, Interior forecasts ample supplies well past the year 2000. Bureau of Mines officials predict present sources will be inadequate to meet needs beyond 1980 if the already limited supply is allowed to escape unchecked.

AIR TRANSPORTATION of liquid helium is still in the experimental stages, but the feasibility of air shipment is being proven by the National Bureau of Standards.

• Paying the piper—Cost of constructing each of the 12 plants would probably run between $15 and $20 million. The entire program could conceivably run in the neighborhood of $800 million over the period 1960-1975.

To amortize the program's cost within 25 years, the price of helium would have to be raised. Today it is produced and sold to government agencies for $15.50 per 1000 cubic feet at the plant site. For non-Federal users, the cost is $19 per 1000 ft. f.o.b. Based on present cost and expenses, Interior has come up with an initial figure of $44.50 per 1000 cubic feet to pay for the program, but this figure may be changed.

Should the legislation be passed, the Government would like to see private industry build and operate the plants, but if there are no takers, the Government will go it alone. Interior says, however, that there has been "a great deal of interest" lately on the part of commercial firms. Should they take over, provision has been included in the bill allowing government to buy the helium at a price insuring the company "a reasonable return" on their investment.

• Nothing like it—Helium is a unique gas. It diffuses more rapidly, flows through a hole faster, conducts heat better, and transmits sound at a higher velocity than any other gas except hydrogen.

Government is the major consumer of the gas, with a little over 50% of all production going to the Department of Defense. The Atomic Energy Commission is the next-largest user.

The major use of helium in rocketry is as an expellant for liquid fuels. It is also used for leak detection and opening and shutting valves, and it is sealed into instruments where inert gas is needed.

Transportation costs are a major factor in both the present use and future development of the gas. Today, cost of transportation usually equals or exceeds the cost of the helium itself. Most is shipped in heavy, high-pressure tank cars having a limited gas capacity. Each car weighs about 200,000 pounds when empty and about 2000 more when filled.

The National Bureau of Standards has studied the feasibility of transporting helium over long distances in liquid form. The Bureau learned that large-scale liquefaction plants and liquid distribution systems compare favorably with compressed gas systems as a means of transportation if the distances and quantities are sufficiently great.

• Cutting leakage—Liquefaction of helium is becoming a common cryogenic technique. Because its liquefaction point, —452°F, is second only to hydrogen's, it has been difficult to hold helium in a liquid state without a great deal of leakage.

Basically, the process of cooling helium to near absolute zero is similar to that used in producing ordinary refrigerator temperatures. Compression of purified helium gas to a pressure of 220 psi yields about 10% liquid when suitably pre-cooled and expanded.

LIQUID HELIUM being produced in the laboratory. This NBS Boulder Lab Engineering Research Tool is capable of putting out about 5 gal. of liquid helium per hour.

The transfer of helium from liquefier to transportable containers is accomplished through pipelines insulated and shielded with liquid nitrogen or liquid air.

The liquefaction facility design adopted after recent studies resulted in a plant capable of condensing helium and delivering it to storage at a rate of 50 gallons per hour. The liquefied gas will then be transported by insulated rail tank car with a capacity of about 13,000 gallons.

Bureau of Standards says that the interest of large consumers, stimulated by the economic and technical feasibility of the accepted design, has extended the studies to the design of facilities with an hourly rate of 260 gallons.

Small quantities of liquid helium are now being shipped by air. The Bureau's Cryogenic Engineering Lab reports it has shipped 12.5 and 19 gal. containers about 2000 miles from the liquefaction source with losses in a typical shipment less than one quarter gallon.

First Lithium-containing Alloy Developed by ALCOA

PITTSBURGH—A lithium-containing alloy developed by **ALCOA** is being tested for missile applications by the Aerospace Industries Association.

Designated X2020, the alloy is the first to employ lithium as a constituent.

X2020 has elastic and compressive moduli some 8% higher than similar alloys. The material has a tensile strength of about 78,000 psi and a strength-to-weight ratio of around 800,000 in.

The elevated temperature properties are excellent. X2020 is useful up to 400°F and, for short periods, almost 500°F.

In processing, the alloy has several distinct advantages—among them, low mechanical properties in the as-quenched condition and slow aging at room temperature. This may eliminate the "ice-box" procedure necessary with other aluminum alloys.

Thiokol Shows Integrated Engines Okayed by Navy

BRISTOL, PA.—Two prepackaged liquid propellant engines were shown for the first time at the opening of **Thiokol's** new manufacturing facilities here recently.

Slated for use in the Navy's *Sparrow III* and *Bullpup* missiles, the powerplants are the first such units to be qualified for operational use by the military.

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moscow briefs

by Dr. Albert Parry

In "Rockets for Transport," a lengthy article in *Sovetskaya Aviatsia*, Professor G. Petrovsky promises that in the near future Soviet passenger and freight rockets will travel from the Soviet Union to Antarctica and back in just one hour or, at the most, one hour and a half. He takes issue with those Doubting Thomases who regard the use of rockets for transport as too expensive to be feasible. Admitting that rocket traffic would indeed be too costly for short hauls, Professor Petrovsky nevertheless insists that for flights "over distances longer than six or seven thousand kilometers" rockets will prove no more expensive than airplanes and "scores of times faster."

To minimize damage from cosmic radiation, man's future spaceships will depart preferably from launching sites situated "closer to the poles." This comes to us in an article in *Komsomolskaya Pravda* by Dr. Sergei N. Vernov, a Soviet astrophysicist specializing in radiation. He writes: "Who knows, perhaps in the future such names as Spitsbergen, Taimyr, and Yukon will designate not only an island, a peninsula, and a river, but also our planet's largest spaceship ports."

Russia's largest astrophysical observatory is now being built in the mountains near Shemakha in the Soviet Azerbaijan (western shores of the Caspian Sea). The weather there is said to be sunny on an average of 200 days a year. Three tall domes over the main building of the observatory will house modern equipment 1450 meters above sea level, and additional instruments will be placed at a nearby point almost 2000 meters above sea level.

In an article on "Aerial Reconnaissance" in *Krasnaya Zvezda*, Major General M. Smirnov (Soviet air force, retired) and Colonel G. Yeletskikh discuss our *Pied Piper* reconnoitering satellite of the future. "The vulnerability of this system," the two Russians writers comment, "is in the possibility that television signals relayed from this satellite can be interfered with, also in a situation where anti-rocket missiles sent to the satellite's orbit will succeed in intercepting the *Pied Piper*."

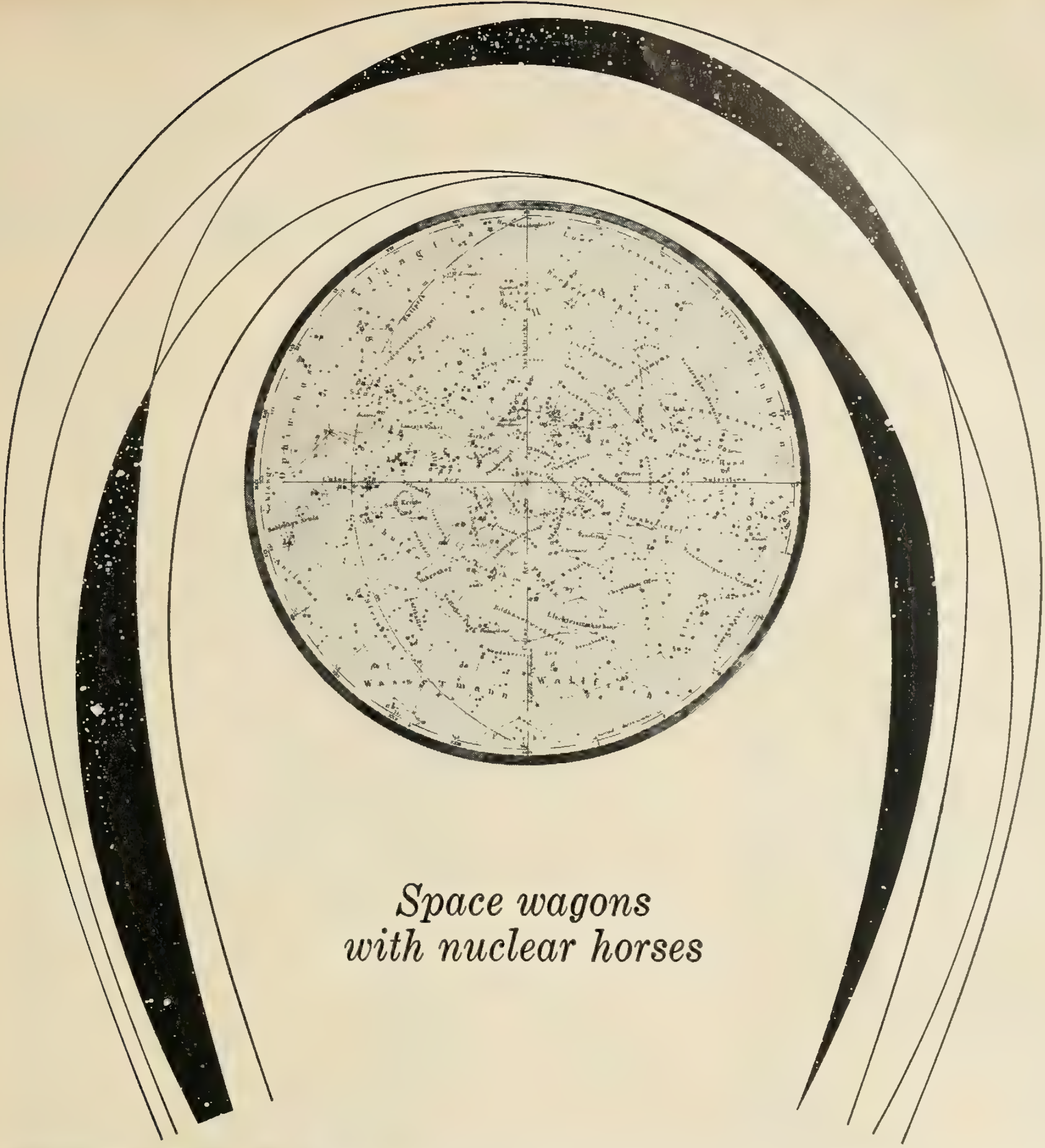
The missile armament of U.S. submarines is the subject of a special article in *Krasnaya Zvezda* by V. Marinin, a Soviet naval officer holding the rank of engineer-captain. The *Polaris* is the main item of his discussion. To illustrate its importance in American planning, the author cites the large 1959 appropriation for *Polaris*—"1,300,000 dollars, or more than the sums appropriated for the *Atlas*, the *Titan*, and the *Minuteman* all put together." After a detailed description of *Polaris* and its intended uses by American submarines, Marinin notes that, despite the large U.S. expenditures, testing of *Polaris* "has not been going too smoothly."

He writes skeptically that, while the first firing from a surface ship is scheduled for 1960, "the degree of success of the use of the *Polaris* on submarines will be shown on a yet more distant day." The Soviet commentator concludes his article by this statement: "No matter how complex the problems of creating guided missiles for submarines, the military groups in the capitalistic countries do not abandon the idea of incorporating such missiles into the armaments of their navies."

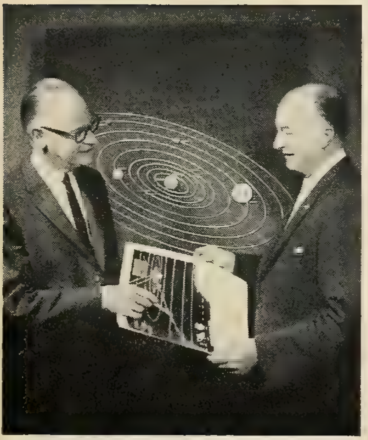
Use of the Maksutov Astrograph (Meniscus) is described at some detail in the article "How We Track *Sputniks*" by V. S. Matiagin and A. V. Kharitonov of the staff of the Astrophysical Institute of the Academy of Sciences of the Soviet Kazakhstan in Central Asia. The article, appearing in a recent issue of the Moscow *Nauka i Zhizn*, also deals with other instruments and methods employed in the Institute's mountain observatory headed by the famous Soviet astronomer, Academician Vasily G. Fesenkov. "The pure mountain air and the large annual number of clear nights help our fruitful astronomical observations," the two authors write. Among the *Sputnik* photographs achieved by this tracking point, they claim "one of the Soviet Union's first pictures of the rocket-carrier of *Sputnik I*."

So tight is Soviet security on the Russian counterpart of our Project *Mercury* that even the fancy and detailed drawing (in several colors) of an astronaut in a recent Moscow article on "Life in Space" was admittedly based "on non-Soviet sources," most likely U.S. publications. The article, by B. Danilin, a candidate of the technical sciences, with illustrations by I Kaledin, appeared in *Tekhnika—Molodezhi*. Apart from data on Laika and other animals of Soviet experiments, it echoes Western sources.

"Radioelectronics and Cosmic Flight" is the title of a brief description of the launching of *Lunik I* in January, 1959, contained in the Moscow *Radio*, the monthly journal of the Soviet Ministry of Communication published for Russian "hams."



Space wagons
with nuclear horses



Space exploration will really come of age when manned rockets can leave earth, accomplish their missions and return without disposing of parts of themselves en route. This breakthrough depends on the rapid development of both nuclear rocket engines and space vehicles capable of using them. Douglas is putting forth a major research effort in the area of manned nuclear space ships. Every environmental, propulsion, guidance and structural problem is being thoroughly explored. Results are so promising that even if the nuclear engine breakthrough comes within the next five years, Douglas will be ready to produce the vehicles to utilize this tremendous new source of space power! Douglas is seeking qualified scientists and engineers for this and other vital programs. Some of our immediate needs are listed in the column on the facing page.

Elmer Wheaton, Engineering Vice President, Missiles and Space Systems, goes over new space objectives that will be made possible by nuclear propulsion with Arthur E. Raymond, Senior Engineering Vice President of

DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

British Ready To Press Space Program

by **G. V. E. Thompson**

London—The result of the recent General Election means that the British Spaceflight Program will at last get under way. The new Conservative government will differ in composition from that before the election, but will continue the same policies.

Approval had already been given to construction of scientific satellite instrumentation to be placed in orbit by U.S. *Scout* vehicles, under terms of an agreement between the two governments. The possibility of building and launching all-British satellite vehicles has been under consideration for many months.

The apparent reluctance to reach a decision on this question was partly influenced by the forthcoming election. Apart from the undesirability of authorising such a program when there was a possibility that another party might take office and cancel or modify it, there was the reaction of the public to consider.

While there has been no sign that the ordinary man or woman disapproves of spaceflight (if anything, the contrary is true), a more critical watch is kept on expenditure at election times. Fortunately, the cost of space research did not become a political issue.

Now that they have been returned to power with an overwhelming majority, it will be possible for the Conservative government to allocate the large sums necessary to build orbital vehicles knowing that it will be several years before they have to account for their actions to the voters. By then the program should be successful.

This is not to imply that the opposition party (Labour) would have refused to participate in space research; they had not reached any definite decision. But Labour was committed to very heavy expenditure in other fields, and might have found it difficult to spare money for astronautics, particularly as some sections of their supporters are strongly opposed to rocket weapons.

British missile firms will now campaign strongly for an early start on the design and construction of British satellite vehicles. They are encouraged by the fact that when Mr. Aubrey Jones (Minister of Supply) opened the Tenth IAF Congress in London he declared himself in favour of the project. He concluded his address by saying that scientifically there was surely no doubt at all but that every State which claimed to bear the banner of civilization should do everything it could to encourage advances in the knowledge of the physics, chemistry, and even the biology of space.

- **Inertial navigation system factory**—A new factory for the manufacture of inertial navigation systems for missiles and other vehicles has been opened by **Ferranti, Ltd.** at Crew Toll, Edinburgh. This is not a completely new venture for the company (which also makes the semi-active homing guidance for the **Bristol** *Bloodhound),* for production of gyroscopes and acclerometers for inertial systems has been going on for the past 18 months.

The new plant has been specially constructed to ensure that the production area is dust-free. Workers arriving have to cross a long mat to remove as much mud and dust from their shoes as possible. Outdoor clothing is left in a cloakroom, then shoes and socks are removed in a changing room divided by a low bench. After swinging round to the other side of this, the workers put on special socks and lint-free carpet slippers. They then proceed to undress and put on special clothing, including a Nylon hat, Nylon overalls and Nylon boots fitting over the slippers; only the face and hands are left exposed. While undressing and dressing, the operatives are subjected to periodic blasts of filtered air to remove loose matter.

The assembly and test areas and the store rooms are temperature, humidity and dust controlled. Components leaving the machine shop have to pass through a system of double air locks to enter this clean area and are first freed from dust by use of ultrasonic cleaners. There is another air lock between the general clean area and the air-conditioned store room.

The air-conditioning equipment is designed to minimize vibration transmitted to the plant. It maintains the air in the plant at a dry bulb temperature of 72°± 1°F. and a relative humidity of 45%. The initial filtration is through glass fibre, but this is followed by large banks of high-efficiency filters, in duplicate to facilitate changing. These remove all particles greater than about 0.5 micron in size and tests have shown that only 0.2% of particles with diameters between 0.1 and 0.5 microns pass the filters.

Sixteen changes of air per hour are provided for the working areas and enter through perforated ceiling domes. Extraction is through floor-level grilles.

The test area is constructed in such a way that the instruments are isolated from ground-transmitted vibrations. Underneath the floor is a large pit containing one 60-ton and two 40-ton blocks of reinforced concrete. One of the small blocks is mounted on 16 helicoil springs and carries a single test pillar. The other two blocks are each mounted on four rubber pads, with rubber side buffers to reduce vibration in the vertical and horizontal planes. The tops of the blocks come to within about one foot of the underside of the suspended flooring over the pit, and carry several aluminum pillars filled with concrete, each weighing about one ton. On these are mounted the test instruments.

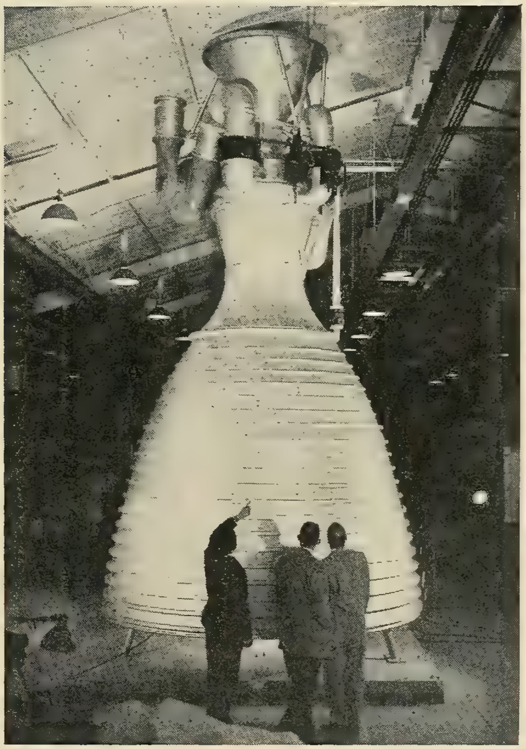
Between each pillar and the floor is a flexible dust seal, designed not to transmit vibration from the floor. Dashpots filled with silicone oil are used for damping.

Few details have yet been released about the instruments being manufactured, but they include a Ferranti-designed pendulous integrating gyro accelerometer, and a single-axis floated rate-integrating gyro. The latter is manufactured under license from the U.S., but will be further developed by Ferranti.

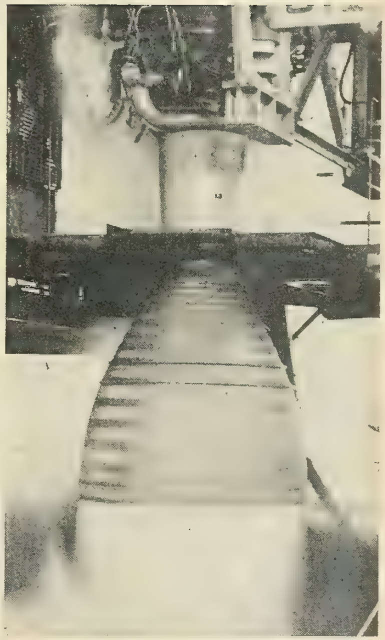
Other British firms working in this field include: **English Electric,** who are going to produce the **Minneapolis-Honeywell** miniature stable platform; **Sperry Gyroscope Co. Ltd.,** who are working on the guidance for *Blue Streak;* and **Elliott Brothers** (London) **Ltd.,** responsible for the inertial guidance of **Avro's** *Blue Steel* stand-off bomb.

Missile News in Recent Pictures

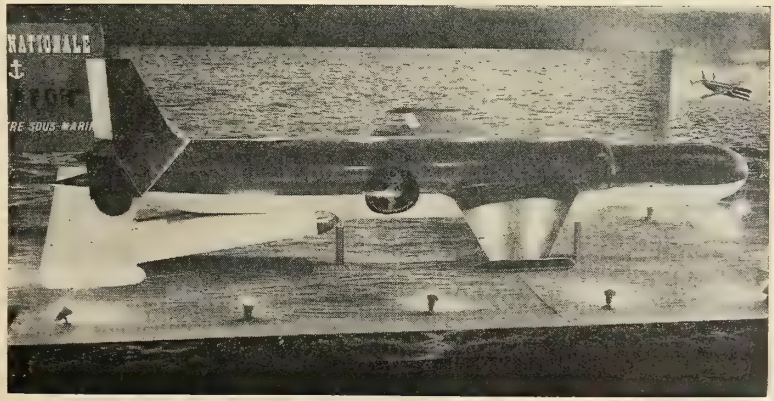
TOP RIGHT—Sweden's Saab J35 Draken fighters carry GE-Philco *Sidewinders* and also are equipped with new, semi-automatic air surveillance gear, part of Swedes' "STRIL 60" air defense system.



LEFT—Full-scale mock-up of Aerojet-General's concept of future space engine. An engine of this type would generate between one and two million lb. of thrust.



RIGHT—First released photo of Rocketdyne's 400,000-lb. thrust class R&D rocket engine being test fired in the Santa Susana Mountains under an Air Force contract.



FRANCE'S ship-to-submarine missile designated *Malafon* was designed and developed by the French Navy. It somewhat resembles U.S. Navy's Convair *Terrier* and French have said they plan to install it on a 5000-ton pocket cruiser still to be constructed.

←

News from Dallas about technical management

Chance Vought in Dallas has realigned into five divisions, giving this 42-year-old company an exciting future in Aeronautics, Astronautics, Electronics, Range Systems and Research — *and giving engineers important advancement advantages.*

Attractive divisional positions are open now for *leaders* . . . men with proved skills in the following activities:

Electronics: Advanced theoretical analysis and application of advanced technology, including the development of advanced methodology in reliability prediction, evaluation and control. Also, planning and implementing practical methods for applying reliability control.

Astronautics: Space communications and antenna systems, and wave propagation in fields of radio frequency, microwave, ultraviolet and infrared systems.

Aerodynamics: Flow and instrumentation work from Mach 10 to 25. Opportunity for top-level instrumentation engineer.

For more information on these and other areas of opportunity for senior engineers and scientists, write:

Professional Placement Office
Dept. P-18

CHANCE VOUGHT
DALLAS, TEXAS

IMPACT AND SHOCK RESISTANCE OF PLASTICS: Final report. N.C. State College for BUSHIPS. Order PB 151729 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 35pp. $1.25.

Placing plastics under a tensile impact load can yield valuable information about their impact resistance, this study revealed.

A pendulum-type impact machine—the Raleigh-Edwards-Tensile-Impact-Machine-Pendulum, or RETIMP—was developed to deliver energy at a high enough level to fracture notch-free specimens of relatively large diameter. The outstanding advantage of the tester is said to be its stability.

Energy delivered from arm to specimen is consistent for any energy and velocity level. RETIMP can be used at numerous energy and velocity levels, facilitating investigation of impact resistance as a function of these two variables.

Specimens of various sizes can be tested to determine relationships between specimen size and impact resistance.

COMBUSTION OF MONOPROPELLANT DROPLETS: THEORETICAL RESULTS, E. Sanchez Tarifa and P. Perez del Notario. Order PB 140776 from Library of Congress Photoduplication Service, Publications Board Project, Washington 25, D.C. Microfilm, $3.60, photocopy, $9.30.

The problems studied include; 1) extension of the integration method for overall reactions of n^{th} order and Lewis-Semenov numbers different from one; 2) comparison of the results for second order chemical kinetics with those obtained by means of numerical integration of the equations; 3) results of the investigation for first and second order chemical kinetics; 4) numerical application for hydrazine, taking the decomposition reaction model proposed by Adams and Stock.

UNCONVENTIONAL ELECTRICAL POWER SOURCES, P. A. McCollum, Oklahoma Institute of Technology for WADC. Order PB 151726 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 104 p. $2.50.

This study is concerned with the production of electrical power generated by means other than rotating machinery and conventional batteries.

Surveyed are the conversion of five sources of energy: mechanical, thermal, chemical, solar, and nuclear.

Specifically, data and theory are presented on the oscillating generator utilizing permanent magnet excitation, the variable reluctance oscillating generator, metal thermopiles, semiconductor thermopiles, thin film thermopiles, fuel cells, p-n junction silicon solar cells, and nuclear converters.

The information was collected through literature surveys, theoretical studies, and experimental work. Aims included the determination of efficiency of energy conversion, weight and size per unit power output, range of voltage and current, life, and reliability.

VOUGHT TAKES AIM AT THE SUBMARINE

Submariners, submarines and sub-launched missiles are intimate friends of a special engineer/scientist task force at Chance Vought.

Vought's ASW team, drawing on a ten-year backlog of comprehensive submarine experience, is working with the Navy and its Fleet units to develop advanced means of protection against attack from under the seas.

Vought engineers have assisted in the design of the missile installation in some of the Navy's newest subs. They have cruised aboard missile subs in pioneering voyages. They have learned the ways and habits of submarines. The company now is applying this valuable insight into virtually every phase of antisubmarine warfare.

Vought's oceanographic studies are designed to discover new, usable information about the submarine's environment. The lay of the land thousands of fathoms down is important in finding and fighting subs.

Fleet subs and aircraft are being operated for Vought in other tests. Under contract with the Office of Naval Research, company scientists and engineers are investigating sub detection techniques which employ new phenomena.

Vought's weapons-wise design and manufacturing teams can be counted on to transform the newest findings into complete and effective defensive systems, in *whatever direction* ASW studies lead.

Antisubmarine warfare, along with atmospheric missile and piloted aircraft development, are specialties in Vought's Aeronautics Division. Other major interests are being aggressively advanced in the company's Astronautics, Electronics, Research, and Range Systems Divisions.

CHANCE VOUGHT
DALLAS, TEXAS

SALT WATER SHELL GAME

Find the sub. It is somewhere in the ocean basins that cover 70 per cent of the earth's surface. Listen for its motors. Find the hum that is lost in the din of marine life. Keep the sub at a safe distance. With one of its nuclear missiles, it can destroy any U. S. city. Don't be decoyed by a single prowler . . . an estimated 450 more subs need watching, too. So go the steps in one of history's toughest defense problems. So runs the routine aboard Navy ships and planes. Round-the-clock work reinforced by the efforts of American industry and ingenuity to provide the equipment needed to cut the Free World's biggest menace down to size.

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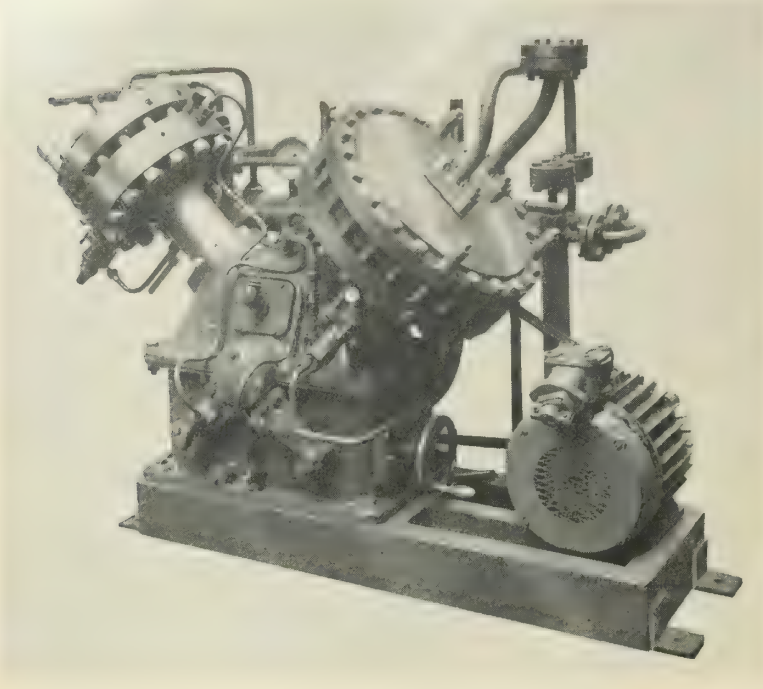


Compressor Leaves Gas Uncontaminated

A French Corblin diaphragm type of compressor which does not contaminate gas under compression is now being marketed in this country by the **American Instrument Co.**

The compressor is said to be completely leak-proof and can pressurize gas up to 30,000 psi in three stages. It has been used to handle such highly toxic and corrosive gases as radioactive hydrogen, oxygen and argon, fluorine, hydrogen fluoride, and hydrogen chloride.

The Corblin compressor's dead space is only about 1 percent of volumetric capacity per stroke. Because of the geometry of the head construction, it can operate efficiently in very high compression ratio, allowing a smaller machine to do a given job.

All parts coming into contact with corrosive gas may be made of such resistant materials as stainless steel, monel, nickel, and Hastelloy alloys.

The compressor functions because of the elasticity of a thin metal diaphragm which alternately flexes in two directions, providing for the suction and discharge of gas. The diaphragm is clamped on its outer edges between two metal plates having concave inner surfaces.

The lower plate has holes through which oil flows from a chamber beneath into the concavity between the diaphragm and the plate. The upper plate contains the suction and discharge valves.

A piston provides the pressurization of the oil in the chamber beneath the lower plate. At the top of its stroke, the piston causes the oil to move forward through the lower plate's holes, which produces the upper motion of the diaphragm.

The piston is driven by a connecting rod from the compressor crankshaft, and is obturated by ordinary piston rings. Leakage of oil is corrected by a piston type compensating pump, keeping the oil chamber full at all times. The pump is pulsed by an eccentric bearing connected at the end of the crankshaft, which injects the oil into the pump chamber in quantities greater than is lost.

Each stroke of the piston forces the diaphragm hydraulically against the inner concave surface of the upper head plate. Because the volumetric capacity of the compression chamber between the plates is greater than the displacement per stroke of the piston, the diaphragm never comes into contact with the lower perforated plate.

The excess oil is returned to the crankcase at the end of each stroke by a pressure valve controlled by spring tension. This tension can be adjusted to permit less and less oil to flow past the valve as the piston rings wear, and more oil is needed to make up for leakage.

The pressure control has a handle with two positions: one allowing spring tension to control the valve, and one for priming the unit to insure the complete filling of the oil chamber.

Gas can be pressurized from atmospheric to a maximum of 220 to 250 psi with one stage of compression. A second stage can bring the pressure to 3600 psi, and a third stage can pressurize the gas to 30,000 psi.

A single stage compressor is normally used when suction is taken directly at the varying pressure within the gas source. Because of the high compression ratios possible with Corblin compressors, the gas may be pumped down from its initial source pressure to pressures approaching atmospheric, and can be discharged into the storage vessel at pressures above that initially used in the gas source.

Liquefied gases are handled by connecting the suction to the empty storage vessel. The compressor sucks residual vapors from the vessel and pumps them into the source, thereby raising the pressure. The gas flows under the applied pressure from the source into the storage vessel.

When all of the gas has been transferred, the valves are reversed and the vapor is sucked from the source and is pumped into the vessel, thereby salvaging all of the gas in both the gaseous and liquid phases.

The compressor also can be used to salvage helium and rare gases from cylinders already considered spent by sucking the residual gases out and pumping them into other vessels which are pressurized to full pressure by taking residual gas from a number of sources.

American Instrument Co.
830 Georgia Ave.
Silver Spring, Md.

'Dacron' Uniforms Solve Lint Problem

Lint, a major problem in industries producing delicate mechanical and electronic components, has been found to be virtually eliminated from manufacturing areas when workers wear new uniforms woven of continuous fil ament yarns of 100% "Dacron" polyester fiber.

This contribution by the textile industry has been especially valuable in the electronics field, as quality tolerances for precision instruments have been continually tightened over the past few years. The presence of lint can critically affect the manufacture and operation of these delicate parts.

A pioneer in using the new uniforms is **Sylvania Electric Products, Inc.**, one of the nation's top producers of electron tubes. The tubes made by Sylvania, a subsidiary of **General Telephone and Electronics Corporation,** are used in data processing equipment, guided missiles, and warning systems. To keep the quality of these sensitive instruments high, it is imperative that the manufacturing area be kept lint-free.

To qualify for use in this plant, the uniform fabric must pass a minute examination under a 10-power magnifier, and show up as a completely smooth, lint-free weave. This can be achieved only with continuous filament yarns, as fabrics made with some of the natural fibers, or with synthetics in the staple form, have a "fuzziness" that generates lint, even though this fuzzy quality may not be detectable by the naked eye. This results from the abrasion of wear, which causes the staple ends to break.

The Du Pont Company, manufacturer of the continuous filament "Dacron" polyester fiber that goes into the new uniforms, is greatly interested in this lint-free aspect which is of such importance to many major manufacturing concerns. The company's Textile Fibers Department accordingly has set up a consulting service on industrial uniforms, to aid firms interested in discussing their lint problems.

Through a personal survey of the local requirements, recommendations are made as to the best types of uniforms and fabrics for the specific needs of the company involved.

Industrial Uniform Consulting Service
Attention: Peter E. Babiy
Textile Fibers Department
E. I. du Pont de Nemours & Co.
Wilmington 98, Del.

'Snap In' Connectors Feature Crimping Design

A new 8-indent crimping design for "snap-in" contact miniature connectors has been announced by **The Deutsch Company**, Electronic Components Division.

The crimp is formed of two rows of 4 indents each, each row having the indents spaced at 90° intervals around the contact barrel. The front row, nearest the mating end of the contact, is slightly deeper than the back row. This forms the wire strands into a ball-or key—between the two rows of indents, thus affording maximum crimp strength with minimum distortion of the wire. On wire sizes accepted by the Deutsch #20 contact, the crimp is greater than the strength of the wire: an inspection hole is provided to assure that the wire is inserted in the contact to the proper depth.

This 8-indent crimp is used with DS miniature environmental connectors. For application with Deutsch DRS miniature rectangular rack-and-panel connectors, a third row of 4 indents is provided as an insulation crimp.

To make this crimp possible, Deutsch has designed and is manufacturing a simple, fool-proof crimping tool—either hand or bench-operated—which makes the quality control of the crimp a function of the tool itself, rather than the operator.

The Deutsch Co.
Electronics Components Div.
Municipal Airport
Benning, Calif.

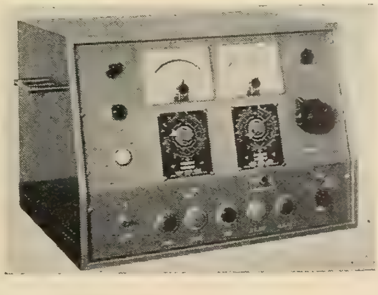
Insulation Breakdown Tester Is Automatic

High voltage breakdown tests of insulation in controls, cables, motors, servos, bushings, and other components as well as assembled electronic systems are said to be simplified and made more dependable by the automatic control offered in the Model 8514 Automatic HYPOT High Voltage Tester, produced by **Associated Research, Inc.**

The new Model 8514 HYPOT allows accurate and dependable voltage breakdown tests to be made with operating personnel that would not be considered sufficiently skilled for less automated equipment.

Sensing and control circuits may be provided in the Model 8514 for fully automated production testing of components, such as motors, controls, capacitors, and transformers.

Some of these automatic control features are: 1. Automatic rate of rise on high voltage d-c test potential. 2. Adjustable automatic shut-off of voltage and leakage current meter. 3. Timer to automatically shunt the leakage current microammeter for 0-5 minutes while capacitance loads are drawing up to a 10 Wa for rapid charging. 4. Timer to apply high voltage control with high speed return to zero.



Associated Research, Inc.
3777 W. Belmont Avenue
Chicago 18, Ill.

Re-entry Attitude Plotted by Dynametrics Instrument

The Dynametrics Corporation announces a new instrument for field evaluation of ballistic missile components.

The nose cone of an ICBM will disintegrate from the violent shock and temperature that builds up as it plunges back into the earth's atmosphere, unless re-entry can be made at the optimum attitude. The Dynametrics Weight and Center of Gravity Locator enables re-entry attitudes to be determined to a high degree of accuracy by providing readout of weight and center of gravity along the roll, pitch and yaw axes.

This instrument measures the mass and center of gravity for the three axes of the nose cone. Based on null-balanced mass and lever principles, the Locator will repeat measurements at all latitudes and altitudes, since it measures essentially mass and mass moments rather than weight. Designed for pre-flight evaluation of ballistic missile components, the W & CG Locator uses precision wind tunnel balance principles to achieve the accuracies required by aerospace vehicles.

The Locator, which can resolve 0.001 inches from maximum weight down to as little as 45 lbs., has an overall accuracy of 0.010 inches over its specified operating range of 1800 to 4500 lbs.

The Locator can handle a complete re-entry vehicle without damaging its critical surface. A special ring is provided for mounting the nose cone to be measured. Measurements are made with reference to the face and axis of this ring as it is rotated by a motor in the weighing yoke. Direct reading of the weight and center of gravity of the missile component are automatically obtained by a flip of a switch for two axes of the cone; then by rotating the cone 90° by the motor, similar measurements are made along the third axis. Polar coordinated measurement may be made by rolling the component to the pisition of maximum radial center of gravity indication and observing the roll angle.

Dynametrics Corporation
Northwest Industrial Park
Burlington, Mass.

RAMJET LEADERSHIP—Ken Hisey (left), Superintendent, Propulsion Shops, discusses some of the finer points of one of the many Marquardt engines with Frank McGuire of the editorial staff of Missiles and Rockets magazine. The pioneering of higher performance ramjet engines by Marquardt has vastly increased the defense area of the advanced Bomarc missile.

WHO READS MISSILES AND

Well, for instance . . . TOP ENGINEERS AT MARQUARDT

Accelerated developments in air-space research . . . advanced power systems . . . manufacturing . . . space-age training . . . and research rocketry have made The Marquardt Corporation one of the foremost leaders in the field of astronautics.

The Marquardt ramjet engines, for example, have been actually flight tested at speeds well over Mach 4 at an altitude of 80,000 feet. Continuous ground cell endurance tests have been successfully conducted to simulate even greater altitudes and higher speeds. In addition to the development and production of propulsion systems that will operate at supersonic speeds, Marquardt has also been a leader in the development and application of high temperature metals and reinforced refractory ceramic coatings for future missiles.

Precision controls and rotating accessories for space vehicles are still another facet of The Marquardt Corporation. A few of these are . . . precision controls for ramjet engines . . . rotating accessories for pneumatic servo actuators . . . and air inlet controls for North American Aviation's "Hound Dog" air-to-surface missile. New and superior production line techniques have been installed at Marquardt's Ogden Division to more than double the production capacity of Bomarc ramjet engines—yet with 100% reliability.

Marquardt is also taking a giant step into tomorrow with ASTRO—Air-Space Travel Research Organization. ASTRO has its own aerodynamic test facilities that are capable of approaching the speed of Mach 12 and temperature tests at approximately Mach 7 (3700° Fahrenheit). Also included in Marquardt's

"Development of products in today's space age is a complex business requiring vast engineering and scientific technology. Additionally, information concerning latest developments in our industry is essential. Missiles and Rockets helps us keep pace in this rapidly expanding market." Don L. Walter, Marquardt Vice President, Power Systems Group.

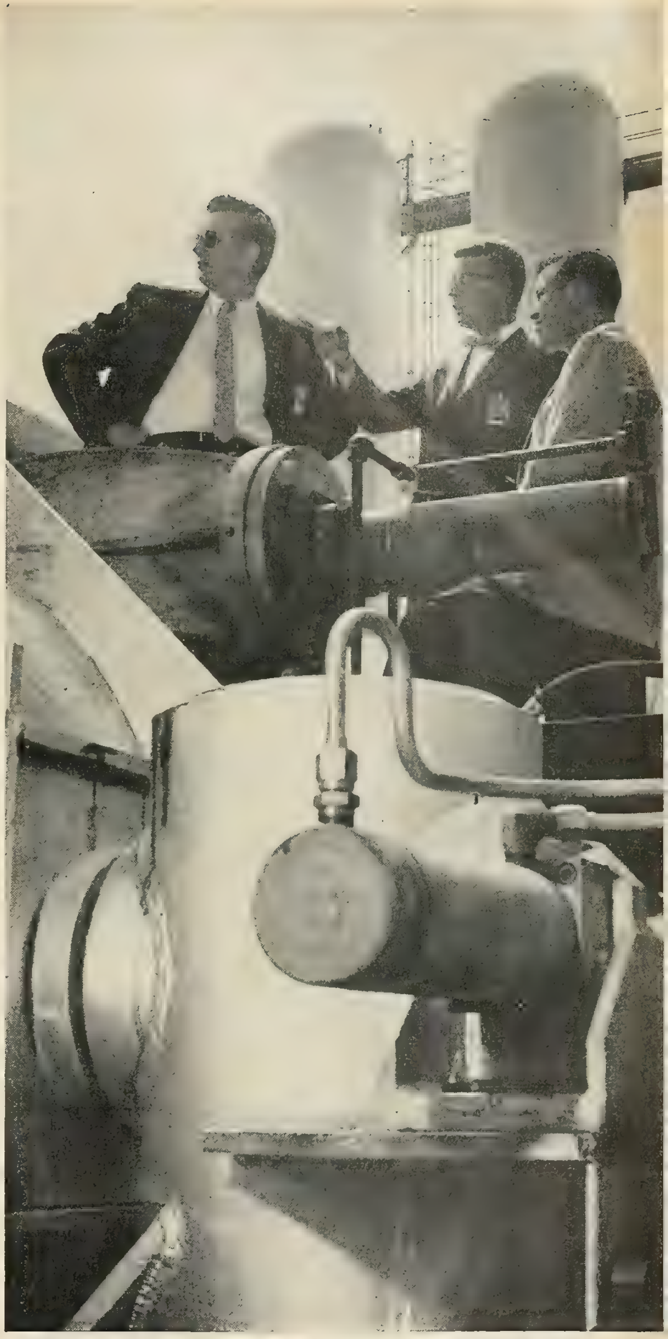
"Today's missile engineers are comparative youngsters with an unending thirst for knowledge of the entire astronautics market. Missiles and Rockets gives us a total, uncluttered picture of what's going on in this field from week to week!" John Widell (left), Project Engineer, Propulsion Engineering.

"If you want pears, you don't order fruit salad. The same holds true in astronautics. We prefer Missiles and Rockets magazine because it deals with astronautics and astronautics *exclusively*." Dick DeSantis (right), Supervisor of Numerical Analysis Section.

ROCKETS?

diversified activities is the manufacture of ground support and handling equipment for missiles . . . systems engineering and equipment for data display . . . development and production of rocket systems . . . specialized solid rocket motors and components for space and missile systems. Marquardt recently established a Nuclear Systems Division in the Power Systems Group. Project Pluto is one of their major programs — aimed at the development of a nuclear ramjet engine.

TELL YOUR PRODUCT OR CAPABILITY STORY TO 29,000 MISSILE TECHNICIANS. . . PAID SUBSCRIBERS . . . THROUGH THE PAGES OF MISSILES AND ROCKETS — TECHNICAL/NEWS WEEKLY OF THE MISSILE/SPACE MARKET.



"The missile engineer must have frequent, technical news concerning the industry. That's why the *weekly* issues of Missiles and Rockets are so important to us. Month old news is of little value when yesterday's developments could easily be obsolete tomorrow." Leigh Dunn (right), Director, Test Section.

M/R

missiles and rockets

AN AMERICAN AVIATION PUBLICATION

1001 VERMONT AVENUE, N. W., WASHINGTON 5, D. C.

Dr. Herbert **R. J. Grosch,** formerly manager of Space Programs-Advanced Programming for IBM's Military Products Division, has joined C-E-I-R, Inc. as director of Corporate Programs and Planning.

GROSCH

Dr. Grosch, a national authority on scientific and commercial applications of high-speed computers, has been in charge of organizing and opening eight major computing and data-processing centers since 1945. In addition to being in charge of the *Vanguard* Computing Center in Washington, D.C., he has directed computing for the Watson Scientific Computing Laboratory and the Washington Technical Computing Bureau of IBM.

Hans W. Weickardt has been named section chief of stress analysis in the research and development engineering division at Solar Aircraft Co.

He comes to Solar from Huntsville, Ala., where he was chief of stress analysis with the Brown Engineering Corp., contractor with ABMA at Redstone Arsenal. Prior to joining the Brown corporation, he was a senior design engineer at Lockheed Aircraft Corp.

W. Hubert Beal has been elected president and chief executive officer of The W. L. Maxson Corp. to fill the vacancy occasioned by the retirement of **Hugo A. Leander,** who was elected chairman of the Board of Directors. **William L. Maxson, Jr.,** son of the founder, its secretary and a director since 1947, was made vice president.

Vitro Laboratories has elected **Clifford E. Suer** project manager of the Mark 37 Mod 1 torpedo weapon system program, succeeding **E. M. Troup,** resigned.

SUER

Suer was formerly head of Vitro's torpedo engineering group and played a key role in developing the Navy's wire-guided torpedo Mark 39. He joined the company in 1956 after two year's service with the General Tire and Rubber Co.

Virgil N. Comsa has joined the newly formed space defense systems group of Electro-Optical Systems, Inc., where he will be engaged in research and development of satellite and space defense mechanisms.

Prior to joining EOS, Comsa was associated with Douglas Aircraft Co. as part of the structures research group assigned to the preparation of reports and data on factors affecting structural design of high-speed vehicles.

Frank K. MacMahon has been appointed manager of military programs for Vertol Aircraft Corp., responsible for overall administration of policies and practices in the firm's defense work.

MacMahon, who joined the company in 1951 as an administrator in the military liaison department, previously served as acting manager of the department he now heads.

Sam L. Ackerman, senior project engineer on the *Atlas* program, has been named to the new post of program director of electronic products for Convair-Astronautics division of General Dynamics Corp.

Ackerman was an Air Force electronics officer during the war, and afterward became assistant manager of Rangertone, Inc. He was a member of the RCA staff at AFMTC from 1954 until he joined Convair in 1956.

Alexander N. Beichek has been appointed assistant director of W. L. Maxson Corp.'s Research Laboratory. He was formerly with the Army Signal Research & Development Laboratories directing design and development of equipment and systems. Prior to that he directed research in tropospheric, ionospheric and outer-space propagation for the Signal Group's Wave Propagation Section.

In his new position, Beichek will direct research in the field of instrumentation, advanced inertial techniques and other projects.

Nortronics division of Northrop Corp., has announced the appointment of **Ross F. Miller** as project manager for the *GAM-87A* guidance system.

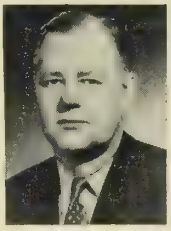
Miller will direct an integrated line project team of research scientist and engineers in the development of an automatic navigation system for the advanced air-to-surface missile. He was formerly chief engineer for the electronic systems and equipment department. **Frank Lynch** has been named to succeed Miller.

Robert E. Whalin, formerly with RCA, has joined Packard Bell Electronics as a liaison engineer for the technical products division and **John M. Evans** has been named manager of special products manufacturing.

Minnesota Mining and Manufacturing Co. has announced promotion of **Dr. R. W. Fritts** to the newly created position of manager, thermoelectric project. Fritts joined the company in 1957 as head of a research team pioneering the development of new semiconductor materials and device technology involving both thermoelectric generation and heat pumping.

Other personnel changes in the thermoelectric program are: **Dr. J. D. Richards,** supervisor for materials research; **William V. Huck,** supervisor for applications research; **William Krawczak** as product development supervisor; **Walter H. O'Neal** as product control supervisor; **Russell Fredrick** as research metallurgist, and **A. D. Steele** as product sales manager.

David Edwin Cordier has been elected technical director of Mesa Plastics Co.


CORDIER

Mr. Cordier, formerly director of research of Plaskon and technical director of Carwin Polymer Products, is a chemical engineering graduate of Purdue University, holds over 20 patents, and is a specialist in resins, polymers and plastics.

William H. Thomas has been elected Washington representative of Air Products, Inc. He will represent all phases of the company's defense and commercial activities in the Capital. **Wesley E. Timmcke** has been appointed East-Central district representative and **Roy H. Price,** Southeast district representative.

John P. Schafer has been named vice president of Hexcel Products Inc. He will continue as a member of the board and will retain his post as secretary.

Howard F. Farmer has been appointed manager of quality control for the Richmond plant of Avco Corp.'s Crosley Division. He succeeds **Richard T. Branch,** who was recently promoted to divisional director of quality and reliability assurance.

Brooks & Perkins, Inc. has announced the promotion of **Earle V. Schirmer** from chief design engineer to chief engineer.

C. E. Huddleston, recently appointed chief engineer, has been named executive vice-president of The Cleveland Punch & Shear Works Co.

James Stacy has been promoted to manager of contract administration of Cooper Development Corp. His previous position as the company's chief estimator has been filled by **Melville Birney.**

Second Test of the *Mercury* Escape System Is Successful

WALLOPS ISLAND, VA.—The second *Little Joe* test, launched last Wednesday to try the escape system in the project *Mercury* capsule, was a complete success, the National Aeronautics and Space Administration reported.

The capsule was lifted to an altitude of 35,000 feet and a distance of five miles before falling into the Atlantic. The escape rockets, located 16 feet above the capsule in a tower, were activated 30 seconds after launch, carrying the capsule several thousand feet from the *Little Joe* booster.

The escape rockets burned for one second and, after a 20-second coasting period, were ejected. About 10 seconds later, the capsule's drogue chute began to break the vehicle's fall, and three minutes after launch—at an altitude of 10,000 feet—the main chute was deployed, easing the capsule into the ocean at 30 feet per second.

A Navy salvage ship recovered the capsule 45 minutes after it was launched.

Two of the four big Pollux engines in the first stage of *Little Joe* were dummies in last week's test, since a short trajectory was desired.

Earnings Reported Higher

A spate of quarterly reports shows earnings of missile manufacturers generally higher than 1958. Items:

For the first nine months of the year, **The Martin Co.** reports net income of $9.4 million, or $3.22 a share, on sales of $377.7 million compared to a net of $7.3 million, or $2.50 a share, on sales of $355.5 million for the corresponding period of last year. Third quarter earnings were $3.2 million on sales of $129.4 million.

Temco Aircraft Corp. reports nine months earnings of $864,000, or 51 cents a share on sales of $77.7 million against earnings of $1.8 million, or $1.07 a share, on sales of $89.7 million for the like 1958 period.

Rohr Aircraft Corp. reports a $2.6 million net, equal to $1.40 a share, on record sales of $191 million for the fiscal year which ended July 31. This compares to earnings of $2.18 a share and a net of $4 million on sales of $147.5 million for the previous year.

Litton Industries reports a net profit of $5.9 million, equal to $3.24 a share, on sales of $125.5 million for the fiscal year which ended July 31. In the previous fiscal year, profits were $3.7 million or $2.13 a share on sales of $83 million, and including a special $1 million income credit.

Minnesota Mining & Mfg. Co. reports nine month sales of $323 million and earnings of $42.5 million or $2.50 a share, compared to sales of $271 million and earnings of $29.5 million, equal to $1.75 a share, for the like period of last year. Third quarter sales were $95 million and earnings $11.9 million.

Borg-Warner Corp. reports $484 million sales and net earnings of $25.6 million for the first nine months of the year. This compares to $396 million sales and a $13 million net income for the like period last year.

Avnet Electronic Corp. earnings for the fiscal year which ended June 30 were $767,000 compared to $235,000 for the previous year . . . Earnings of **Daystrom Inc.** jumped to $802,000 for the first six months of the year—more than double the $369,000 profits for the comparable 1958 period . . . and the nine months net of **Air Reduction Co.** was $11.4 million against $9.7 million for the same 1958 period.

AF Calls Briefing On New Solid Rocket

EDWARDS AFB, CALIF.—The Air Force will hold a contractor briefing here Nov. 10 on a requirement for a solid-propellant rocket with twice the thrust of *Minuteman*. Thrust of the 55-foot **Boeing** *Minuteman*, which is designed to hurl a one-megaton warhead more than 8000 miles, is classified.

The announcement gave rise to speculation that the AF may be seeking a second-generation *Minuteman*-type ICBM that can carry a larger nuclear payload. Higher thrust solid motors also would have space applications.

GM Wins AF Contract For Satellite Powerplant

The Air Force awarded a contract to **General Motors** for design, fabrication and testing of an earth satellite powerplant. The powerplant is being developed by the GM's Research Division and Allision Division.

Lockheed Corp. has built a test facility at Cape Canaveral for the *Midas* early-warning satellite system. More than 200 scientists, technicians and administrative personnel are expected to take part in the ARPA Air Force program at the Cape.

The Air Force scratched one of its five **Douglas** *Thor* squadrons. Previously it planned to hold the 15-missile squadron in reserve. The four others are being stationed in England and manned by British troops.

Engineer Gets Prize For Design of Pads & Fences

WASHINGTON—The Department of Defense has awarded $750 to Curtis A. Anderson of Mariemont, Ohio, for designing launch pads at Cape Canaveral and jet blast deflection fences at Startegic Air Command bases.

Anderson is chief of the instrumentation and special studies branch of the Ohio River Division Laboratories, Army Corps of Engineers.

He conceived of the bowl-like blast deflectors that distribute and disperse discharged gases evenly around launch pads and static test sites. Previously, launch pads were often destroyed when missiles were fired.

His blast deflection fences applied the principle of the venetian blind to channel and dissipate blasts from jet aircraft during maintenance and warm-up operations.

The cash prize was given in connection with a special DOD distinguished Civilian Service Award.

Rare-earth Metals Made Available in Fine Powders

NEWARK, N.J.—Rare-earth metals are now available in finely divided powder form.

Cerium Metals and Alloys Division of **Ronson Metals Corp.** announced recently that it has powders of any desired size down to 325 mesh in cerium, lanthanum, didymium, misch-metal and other rare earths and alloys. The company also produces the metals, in purities from 99.5% to 99.9% in ingots, rods, pellets and turnings.

more about the missile week

- **Pittsburgh**—Deputy Defense Secretary Thomas S. Gates said the steel strike was crippling the *Atlas, Titan* and *Polaris* missile programs. As of mid-October, he said, delivery dates of **Convair** *Atlases* were being extended one day for every day of the strike. He said two to three months delay in construction of four *Atlas* and *Titan* bases is already anticipated. And he said production of at least one essential *Polaris* component had been halted and curtailment of others was expected shortly.

- **Washington**—President Eisenhower ruled out military exploration of the moon. He told a weekly news conference projects directed at the moon were strictly scientific, and therefore should be handled by a civilian agency—NASA—in line with long-standing national policy of assigning to the military only those missions which fall within its province. He said he could see no reason for using—or misusing—military talent to explore the moon.

- **Washington**—Members of the House Space Committee set out on a tour of West Coast and Southwest missile production facilities for an "informative-type" study of high-thrust engine programs.

- **Ordill, Ill.**—During a solid rocket fuel mixing and casting operation, an explosion destroyed a small research building in the **Olin Mathieson** plant, killing one employee. The exact amount and type of propellant involved were not disclosed. But, the mixture was said to be part of a 2000-pound grain.

- **Philadelphia**—GE Satellite Engineer Robert P. Haviland predicted that within 10 years missile-boosted space vehicles will be able to ride in on a radio beam and land at a predetermined point. He said such a space vehicle could deliver within minutes thousands of pounds of emergency medical supplies to a disaster area.

- **Cape Canaveral**—A **Douglas** *Thor* roared 1700 miles down the Atlantic Missile Range on a "routine test flight." The shot brought the *Thor* launching score to 51—34 successes, 10 partial successes and 7 failures.

- **Washington**—Charles Critchfield, **Convair** director of scientific research, has been named successor to ARPA Chief Roy Johnson. Johnson is expected to leave the post within about a month.

- **Washington**—An attempt will be made to sell about 50 Air Force-owned aircraft plants to the companies now occupying them . . . The Air Materiel Command is establishing an electronic systems center at Hanscom Field, Mass., near Boston.

- **Washington**—Impact of strategic missiles being phased into the Air Force is causing a sharp drop in pilot training—2500 this year compared to 3600 in 1958 and 5800 in 1955. Rated pilots on flying status have decreased from 57,000 in 1957 to 54,000 and aircraft in inventory has dropped from a 1956 peak of 24,536 to 19,416.

- **St. Louis**—A polysonic $5.3-million airflow laboratory which includes a 4000 mph wind tunnel is now in operation at **McDonnel Aircraft Corp.** It is the last element of a four-year, company-financed $34-million expansion program.

- **Washington**—The Labor Department is holding a meeting with industry Nov. 19 preparatory to issuing a questionnaire which will survey minimum wages in the aircraft industry. The survey will bear on the question of whether the aircraft industry should be expanded to include at least some phases of missile production. The electronics industry is not included.

Mergers & Expansions

Switching the usual merger roles, **Microdot Inc.**, small South Pasadena, Calif., miniature cable maker, has purchased the **Westinghouse Corp's** specialty transformer division at Los Angeles . . . **Electronic Research Associates**, Cedar Grove, N.J., has acquired **Advanced Acoustics Corp.** . . . Two large steel fabricators, **Pittsburgh-Des Moines Steel Co.** and **Hammond Iron Works**, Warren, Pa., have merged . . . A substantial interest has been acquired by **Copper Range Co.** in **The Alloyd Corp.**, Watertown, Mass. . . . At Niles, Ill., **American Machine & Foundry's** Mechanics Research Division is taking over a new 30,000 square-foot laboratory . . . **Industrial Electronic Engineers Inc.** has moved into a larger plant at North Hollywood, Calif. . . . The European subsidiary of the **Burndy Corp.**—**Burndy Electra**—is building a new plant at Malines, Belgium . . . **Bytrex Corp.**, Newton, Mass., and **Kulite Semiconductor Products**, Ridgefield, N.J., have formed a jointly-owned subsidiary—**Kulite-Bytrex Corp.**—to manufacture semiconductor strain gages . . . Newly opened West Coast plants: **Weston Hydraulics Ltd.**, a subsidiary of **Borg-Warner Corp.**, is now in a 100,000 sq. ft. facility at Van Nuys, Calif., and at Sunnyvale, Calif., **Avnet Electronics Corp.** of Northern California has an 11,000 sq. ft. factory . . . The **Autonetics Division** of **North American Aviation** has established separate product divisions for armament and flight controls, computer and data systems, inertial navigation and industrial products . . . Plant expansions are underway at **Networks Electronic Corp.**, Van Nuys, Calif., and **Heinemann Electric Co.**, Trenton, N.J. . . . **Clevite Transistor Products Division** of **Clevite Corp.**, is putting up a multi-million plant at Waltham, Mass., which will employ 1500 persons . . . **Waltham Precision Instrument** has acquired more manufacturing space at Brookfield, Conn. . . . and at Detroit, **General Motors Corp.** has formed a new, non-manufacturing Defense Systems Division . . .

GE To Start Building $14-million R&D Center

PHILADELPHIA—The **General Electric Company** will soon begin construction of a $14 million center to provide space for expansion of its missile and space vehicle R&D work.

The new center will be part of GE's Missile and Space Vehicle Department and will be located on a 130-acre site 17 miles west of here at the junction of the Pennsylvania Turnpike and the Schuylkill Expressway, near historic Valley Forge.

H. W. Paige, general manager of the MSVD, said ground-breaking and other pre-construction work will begin before the year is over, and part of the center will be occupied in late 1960.

propulsion engineering . . .

By JAY HOLMES

Public interest in the booster program . . .

has grown suddenly as a result of Russia's spectacular success with the *Luniks*. Major rocketmakers are seizing the opportunity to press some of their more elaborate ideas for space propulsion. They figure there is no better time than the present to let the man in the street know how he can contribute to catching up with Russia in the race for space—that is, if we are in a race.

The latest such plan is Aerojet's Project Cosmos . . .

which the company calls a new approach to building big, liquid-fueled boosters, ranging from 6 million to 14 million pounds thrust and more, which could enable the U.S. to put a man on the moon in four years.

Project *Cosmos* is a plan for simplifying the engineering of a big booster rocket. In the trade-off between performance on the one hand and cost and development time on the other, some performance would be given away to accelerate development and reduce cost. A side advantage would be increased reliability, **Aerojet** says. For example, a *Cosmos*-concept rocket would be more rugged structurally, although it would be heavier than necessary under present lines of development.

Aerojet declines to reveal further . . .

details about the *Cosmos* proposal. A spokesman says anything additional would endanger the company's proprietary rights. The concept is not a new propellant combination. It can be used with any of the existing combinations—LOX, storables or high-energy.

Although no cost figures were mentioned, Aerojet spokesmen said the concept could be tested in a relatively inexpensive initial-year experimental feasibility-development study. Aerojet said it has spent $400,000 of its own money and 40,000 man-hours of staff time examining the concept.

The plan is not married . . .

to any specific size of engine. Aerojet says one major outlay will be needed to prove that the concept is workable—then a minimum additional expense to vary thrust over a considerable range. Also, it can be varied to provide for recoverability of the booster.

Project *Cosmos* was presented to officials of the Defense Department and NASA. Spokesmen for both government bodies declined comment pending study. However, a NASA official pointed out that use of the name *Cosmos* was selected by Aerojet and has no official sanction.

Cosmos is in competition . . .

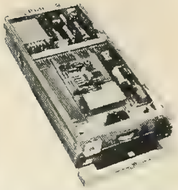
with the **Thiokol** plan for a 10-million-pound, 60-second solid-fuel booster, announced last month by Dr. Harold Ritchey. Another entry in this sweepstakes is a more modest million-pound-thrust solid booster proposed by D. F. Sprenger of Aerojet.

Ritchey and other solids men argue that less time and cost are involved. Further, they say, solids are more reliable. Liquid-engine advocates challenge each point, of course.

Rocketdyne, of course, has plans, too . . .

The **North American** division has the E-1 already developed, the F-1 under development and the L-1 on file if anyone wants something even bigger. E-1 has 400,000 pounds of thrust. The F-1, a single-chamber engine with 1,500,000 pounds of thrust, is in the first year of a four-to-six-year NASA development timetable. L-1 is a blueprint for the next generation after F-1—a single chamber-burning LOX-RP end generating 12 million pounds of thrust. It would pump 24 million pound of propellant a minute.

What kind of mission for L-1? A Rocketdyne spokesman said he couldn't remember just what was proposed but it was something like putting the City of Chicago into orbit.



N E W

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First . . . truly operational solid state subcarrier discriminator . . . completely transistorized . . . phase lock circuitry . . . plug-board replaceable assemblies . . . frequency capabilities to 300 KC . . . calibrated output voltage controls . . . individualized meter design . . . self-contained power supply . . . approx. 27 watts input . . . weighs only 12 pounds.

First of an all new and complete line of DCS solid state telemetry equipments. We invite your inquiries about our Model GFD-3.

!

This subcarrier discriminator to be used by Boeing for "Minuteman" ground data reduction function. Another example of DCS leadership in telemetry.

DATA-CONTROL SYSTEMS, Inc.

DCS

39 Rose St.,
Danbury, Conn.

NASA

$[illegible]—Republic Aviation Corp., for an investigation of lunar and interplanetary space probe trajectories.

NAVY

$3,250,000—**Vitro Laboratories**, Silver Spring, Md., for systems engineering work on the *Polaris* missile.

$1,000,000—**Electronics Div. of Webcor, Inc.**, Chicago, for airborne electronics equipment used to detect the presence of enemy submarines and other classified equipment.

$600,000—**Hallamore Electronics Div., The Siegler Corp.**, for design, manufacture and installation of electric instrumentation and systems control equipment in connection with the *Polaris* missile.

$280,870—**Northeastern Engineering, Inc.**, Manchester, N.H., for switch-boards, electrical, for missile power.

$259,200—**New Hampshire Ball Bearings, Inc.**, Peterborough, N.H., for 65,400 advanced-design ball bearings to be used in the *Sidewinder* air-to-air missile. Subcontract from **Farmers Tool & Supply Co.**, Denver.

$200,000—**Electronic Systems Development Corp.**, subsidiary of **Solar Aircraft Co.**, for development, manufacture and installation of a precision radar synchronization system linking all the tracking and surveillance radar facilities to the Pacific Missile Range.

$95,000—**Chance Vought Aircraft, Inc.**, Dallas, for engineering services and materials necessary to conduct the *Regulus I* weapon system support program.

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$30,820—**Southern Research Institute**, Birmingham, Ala., for an investigative program to assess the significance for design purposes of experimental techniques for evaluating the resistance of high-strength structural alloys to catastrophic failure by brittle fracture.

AIR FORCE

The Sheffield Corp., Dayton, Ohio, Subsidiary of **Bendix Aviation Corp.**, for research and development to evaluate the application of high-frequency vibrations to grinding operations. Amount not disclosed.

$2,820,000—**Hughes Aircraft Co.**, Culver City, Calif., for *Falcon* missile composite flight test program.

$2,394,829—**Eastman Kodak Co.**, for various types of aerial film.

$1,000,000—**Ford Instrument Co., Div. of Sperry Rand Corp.**, for building and testing an experimental model of a radically new airborne inertial navigation system, designated the AJN-7.

$550,800—**Melpar, Inc.**, Falls Church, Va., for study and development of a speech compression system.

$488,051—**Aerojet-General Corp.**, Azusa, Calif., for rockets.

$400,000—**Hallamore Electronics Div., The Siegler Corp.**, for further development and installation of closed circuit television, ground instrumentation and other data acquisition equipment for the *Titan*. Subcontract from **The Martin Co.-Denver.**

$270,000—**Budd Lewyt Electronics, Inc.**, N.Y., for research and development of transistorized equipment for a classified mission.

$129,980—**Sylvania Electric Products, Inc.**, N.Y., for electron tubes.

$124,890—**Raytheon Co., Microwave & Power Tube Div.**, for electron tubes.

$100,000—**Massachusetts Institute of Technology**, for investigation of the interaction of high powered R.F. energies and high density plasmas.

$84,150—**North American Philips Co., Inc.**, for electron tubes.

$51,625—**General Electric Co.**, Scranton, Pa., for electron tubes.

$49,500—**Penta Laboratories, Inc.**, Santa Barbara, Calif., for electron tubes.

$40,000—**American Meteorological Society**, Boston, for research directed toward abstracting and bibliographic services in the field of meteorology.

$30,392—**Sperry Rand Corp., Electronic Tube Div.**, for electron tubes.

ARMY

Kearfott Co., Inc., subsidiary of **General Precision Equipment Corp.**, for conducting a design study program for an automatic resolver tester. Amount not disclosed.

$3,400,000—**International Telephone & Telegraph Corp., Federal Division**, Clifton, N.Y., for production of *Lacrosse* missile guidance units. Subcontract from **The Martin Co.-Orlando.**

$2,176,040—**Bendix Aviation Corp., Frieze Instrument Div.**, for meteorological equipment.

$236,550—**Electronic Associates, Inc.**, Long Branch, N.J., for three transformation computers.

$179,880—**Electro-Optical Systems, Inc.**, Pasadena, Calif., for investigation of ionized gases.

$167,140—**Raytheon Co.**, Andover, Mass., for concurrent repair parts for the *Hawk* missile.

$128,600—**Western Electric Co.**, N.Y., for *Nike* spare parts and components.

$112,000—**Cardinal Building & Constructors, Inc.**, Plattsburgh, N.Y., for construction of missile run-up shop.

$96,977—**Transitron Electronic Corp.**, Wakefield, Mass., for research and development leading to development of high-efficiency silicon solar cells.

$83,036—**Dynametrics Corp.**, Burlington, Mass., for the design and fabrication of a data recording system.

$75,000—**The Dow Chemical Co.**, Tulsa, Okla., for developing and applying a practical procedure for cleaning *Saturn* missile parts and components.

$66,459—**Aeronutronic Systems, Inc.**, Glendale, Calif., for conducting research in the guided missile and range instrumentation field in the telemetry area technical reports.

$35,150—**Minneapolis Honeywell Regulator Co.**, Aeronautical Div., for components for laboratory evaluation tests in connection with *Sergeant* missile system.

$33,355—**United Engineers, Inc.**, Springfield, Mass., for design and fabrication services.

MISCELLANEOUS

Electronic Communications, Inc.'s Advanced Technology Corp., for ICBM guidance study. Subcontract from **Lockheed Aircraft Corp.** Amount not disclosed.

$400,000—**Radiation, Inc.**, Melbourne, Fla., for a highly advanced PCM flight test acquisition and data processing system for use in the N-156F program. Subcontract from **Northrop Corp., Norair Division.**

$340,000—**Polarad Electronics Corp.**, N.Y., for a completely automatic signal generator for use in a classified project. Subcontract from **Boeing Airplane Co.**

$217,625—**Servomechanisms, Inc.**, Hawthorne, Calif., for magnetic amplifiers and transformers for the MA-1 and MG-13 Aircraft Weapons Control Systems. Subcontract from **Hughes Aircraft Co.**

$106,000—**Yardney Electric Corp.**, N.Y., for manufacture of silver-zinc batteries for missile application. Subcontract from **Boeing Airplane Co.**

* * * * * * * * *

NASA announced that it awarded the following contracts during September. (Most of them have been reported in M/R previously):

$2,000,000—**Bendix Radio Div., Bendix Aviation Corp.**, for operation of minitrack stations for 1960.

$140,000—**Minneapolis-Honeywell Regulator Co.**, for fabrication of a guidance and control system for *Scout*.

$110,000—**Instituto Geofisico de Hyancayo**, for operation of tracking and receiving station at Lima, Peru.

$110,000—**Geophysical Corp. of America**, for instrumentation to measure electron density in the ionosphere.

$100,000—**Pratt & Whitney Division, United Aircraft Corp.**, for investigation of heat transfer potentialities of a number of materials in a near-vacuum under extremely high temperatures that would be encountered in a nuclear-electric generating system.

$90,000—**University of Michigan**, for basic research on the plumbing erosion that occurs under high temperatures in certain rocket engines.

$73,000—**Republic Aviation Corp.**, for study of lunar and interplanetary space probe trajectories.

$50,000—**Society of Photographic Scientists and Engineers**, for operational expenses for volunteer photo and radio tracking of earth satellites.

$50,000—**Thiokol Chemical Corp.**, for spherical rocket motors for re-entry research.

$50,000—**Avion Division, ACF Industries, Inc.**, for radar tracking beacons for *Scout*.

—reviews

THE EXPLOSIVE PRESS AS A RESEARCH TOOL IN MATERIAL BEHAVIOR AND FORMING, E. W. LaRocca and J. Pearson, U.S. Naval Ordnance Test Station, China Lake, Calif. Order PB 151844 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. $.50.

Expendable explosive presses were devised for research in explosive forming of powdered metals and non-metals, as well as expensive materials.

Unlike most metal explosive systems, the presses permit recovery of the test specimens. Presses are single and double action. The double action press, which is of sandwich-type construction, uses two explosive charges fired simultaneously to drive two opposed pistons together into a central steel cylinder in which the specimen material has been placed. Pressures of several million pounds per square inch can be obtained.

By modifying the working faces of the piston, materials can be formed into various shapes. Text and line-drawings in this report describe the action of the presses and their application to several materials.

STATUS REPORT ON FUEL CELLS, B. R. Stein, Army Research Officer. Order PB 151804 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 119p. $1.25.

A recently appointed Army Fuel Cell Steering Committee has gathered data on advancements in the field and published its first report of the current status of fuel cell development.

All fuel cell activities currently pursued or planned by the Army are described, as well as some of the work of other agencies.

The report reviews military requirements and interest and contains a general description of the fuel cell operation, descriptions of a variety of fuel cell systems, a general discussion, a review of the Dept. of Defense supported program, a summary, and references.

ADVANCED PROPULSION SYSTEMS, H. F. Calcote, AeroChem Research Laboratories, Inc. for ONR. Order PB 151796 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 105p. $2.50.

A critical look at the mid-1958 state of the art of advanced propulsion systems and prospects for their future development is taken in this report of a study for the Office of Naval Research.

Conclusions reached included: Possibilities of very high specific impulses from free radicals are limited by their low densities and other problems such as storage. Excited chemical species and noble gases, also high specific pulse possibilities, need more basic research. So does the oxygen-atom recombination ramjet.

In electrostatic propulsion ion-rockets, major problems exist in the separation of electric charges. Magnetogasdynamic propulsion, with no problems of charge separation, appear more promising.

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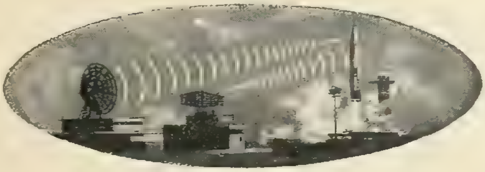

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- Engineering Psychologists
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- Weapons Analysis Engineers
- Weapons Systems Integration Engineers
- Engineering Writers

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missile business . . .

By **WILLIAM E. HOWARD**

For 35 cents missile contractors can now avail themselves of the latest Defense Department edict on cost principles (Revision No. 50, Armed Services Procurement Regulation) published by the Government Printing Office. This new regulation, says DOD, is the product of years of study. And while it establishes some new rules on allowable costs generally, its principal affect is to liberalize chargeable costs incurred by R&D contractors.

The new cost principles do not cover either . . .

negotiated contracts or profits. Rather they are designed to "serve as the contractual basis for the payment of costs under cost-reimbursement type contracts." And in all other contracting or contract settlement situations, says DOD, "they will serve as a guide in the negotiation of prices or settlements, to the extent that the evaluation of costs is necessary for the setting of fair and reasonable prices."

To the R&D contractor the new ruling provides that his independent research and development costs will be allowed as indirect costs —if the development work is related to product lines for which the Government has contracts, and if the costs are reasonable.

These costs will include a share of indirect . . .

and administrative costs. But R&D costs which were incurred in accounting periods prior to the award of the specific contract generally are not permitted.

What are "reasonable" expenditures? In arriving at this often seemingly nebulous quantity, DOD contract officers are instructed to take into account such factors as previous contractor R&D activity, cost of past programs, and changes in science and technology. Such expenditures by the contractor must follow "a broad planned program, which is reasonable in scope and well-managed."

Some other cost principles which are revised . . .

include: advertising costs—allowable in limited areas only (ads pushing a particular weapon system or lobbying are out); profit-sharing plans for executives—allowable to the extent that an individual's total compensation is considered reasonable; contingency costs—allowable in settlement of contract terminations and in connection with estimates of future costs in certain areas; interest—not allowable; materials—allowances are expanded to include sales and transfers between plants; plant reconversion costs—restoration after the removal of government property is allowable.

Severance pay after contract termination would be allowable only in individual contract agreements. State and local taxes are allowable if they have been imposed upon work in progress or inventories—and if the instructions of the contracting officer are followed in cases where the taxes are thought to be illegal.

The rules also establish for the first time the principle that cost factors may be used as "guidelines" in the negotiation and administration of fixed-price type contracts.

Procurement officials deny that contractors . . .

will be forced into adopting new cost accounting systems. They also claim that the principles will not lead to formula pricing.

What do they all add up to in the way of plus or minus money for DOD? Says a spokesman:

"In the fixed price area, we expect that the new principles will ultimately result in more efficient procurement and, hence, savings will accrue in the long run. It is not possible to put a dollar sign on any such savings at this time."

—when and where—

NOVEMBER

Institute of Radio Engineers, Fourth IRE Instrumentation Conference, Biltmore Hotel, Atlanta, Nov. 9-11.

Operations Research Society of America, Sixteenth National Meeting, Huntington-Sheraton Hotel, Pasadena, Nov. 11-13.

National Academy of Sciences, Autumn Meeting, Indiana University Memorial Union, Bloomington, Nov. 16-18.

University of Michigan, Fifth Annual Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Nov. 16-19.

American Rocket Society, 14th Annual Meeting, Sheraton-Park Hotel, Washington, D.C., Nov. 16-20.

American Society of Mechanical Engineers, Fifth International Automation Exposition and Congress, New York City, Nov. 16-20.

Instruments Division, Philips Electronics, Fifth Norelco Electron Microscope School, Hotel Victoria, New York City, Nov. 16-20.

National Aviation Trades Association, 20th Annual Convention, Hotel Montelone, New Orleans, Nov. 16-20.

Society of Aircraft Materials and Process Engineers, Eastern Division, Fall Meeting, Sheraton Carlton Hotel, Washington, D.C., Nov. 17.

Institute of the Aeronautical Sciences, National Turbine-Powered Air Transportation Meeting, Fairmont Hotel, San Francisco, Nov. 17-18.

Institute of Radio Engineers, 1959 Northeast Electronics Research and Engineering Meeting, Boston Commonwealth Armory, Boston, Nov. 17-19.

Ninth Aircraft Hydraulics Conference, sponsored by Vickers, Inc., Div. Sperry Rand Corp., Park Shelton Hotel, Detroit, Nov. 18-20.

DECEMBER

AFOSR/Physics Division, Physical Sciences Directorate and NAS/NRC, Conference on Problems Related to Interplanetary Matter, Northwestern University, Evanston, Ill. (Dates still not firm).

Rocket and Missile Symposium, USAF Arnold Engineering Development Center and ARO, Inc., Arnold Air Force Station, Tullahoma, Tenn., Dec. 1-2.

Eastern Joint Computer Conference, Statler Hilton Hotel, Boston, Dec. 1-3.

National Conference on Application of Electrical Insulation, Sheraton-Park and Shoreham Hotels, Washington, D.C., Dec. 6-8.

American Institute of Chemical Engineers, 52nd Annual Meeting, Sheraton-Palace Hotel, San Francisco, Dec. 6-9.

American Management Association, Briefing Session on the Defense Market, Ambassador Hotel, Los Angeles, Dec. 7-9.

First Aerospace Finishing Symposium, sponsored by Southwest Society of Aircraft Materials and Process Engineers, and Dallas-Ft. Worth Branch of American Electroplater's Society, Hotel Texas, Fort Worth, Dec. 8-9.

Institute of Environmental Sciences, New York Metropolitan Chapter, Technical Symposium and Product Exhibition, Henry Hudson Hotel, New York, Dec. 10-11.

1960

Sixth National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

American Astronautical Society, Sixth Annual Meeting, New York City, Jan. 14-20.

Institute of Radio Engineers, 1960 Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles, Feb. 3-5.

Univac Users Association, Semi-Annual Meeting, Greenbrier Hotel, White Sulphur Springs, West Virginia, Feb. 25-26.

American Rocket Society, Structural Design of Space Vehicles Conference, Biltmore Hotel, Santa Barbara, April 6-8.

American Welding Society, 41st Annual Meeting and Welding Exposition, Los Angeles, April 25-29.

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editorial

Keep the Military in Space Race

The awarding of a development contract for the last remaining military space system, *Dyna-Soar,* has been held up for many months now. The competition for this boost-glide, manned and winged space vehicle is between teams headed by the Boeing and Martin companies.

In September, General Bernard Schriever, boss of the Air Research and Development Command, said it was being delayed for another look at the propulsion and guidance systems.

Just a few days ago, following the announcement from the White House that the Army Ballistic Missile Agency at Huntsville was being turned over to the National Aeronautics and Space Administration, Wernher von Braun, head of the old Army space team, made a rather significant statement.

The payload for *Saturn,* he remarked, might be a winged vehicle. *Saturn,* the cluster of eight Rocketdyne engines designed to produce 1.5 million pounds of thrust in one bundle, is the chief project of the ABMA.

A "winged vehicle" presumably would be *Dyna-Soar* or a similar vehicle, winged and manned for control and re-entry.

Actually, the nation has no booster at the moment capable of lifting a *Dyna-Soar* type spacecraft. The F-1, Rocketdyne's 1.5-million-pound-thrust single engine, was projected with *Dyna-Soar* in mind. Martin's bid for the contract is thought to involve clustering several Aerojet-General *Titan* engines. The F-1 was taken from the Air Force and given to NASA, where it progresses slowly for lack of funds. The Martin approach is in a design study stage.

Saturn might be the answer, if Von Braun and his team can get the money they are clamoring for to bring the project to operational status before it sprouts moss—and if *Dyna-Soar* is finally approved.

But this brings up a major and most important point. Will *Dyna-Soar,* under any name, remain a military project or will it too be transferred to the civilian space agency?

At the moment all space projects except *Dyna-Soar* have been taken from the military. The services have no space mission according to the Administration viewpoint, and there are even recurring reports that an unwritten order limits their operations to 600 miles above the earth.

We have sincere doubts that this is wise and we believe it is one of the things the House Space Committee will want to look into when it conducts the full committee investigation of our national space program, now announced as first order of business when Congress reconvenes in January.

For we believe the services do have a mission in space and that the nation can use the talents and the experience of the military; that the sense of urgency inherent in the military usually does not exist among civilian scientists; that—above all—the military has the sworn task of defending this country and that the battle for space—with the knowledge, experience, prestige and strategic advantage it can bring us—*is a war which we dare not lose.*

Dyna-Soar is a man-in-space program, but more than that it is the first program promulgated by the U.S. which puts a man into space for a reason other than to see if he can survive.

The Project *Mercury* Astronauts will be fired aloft in capsules, observe and report. The *Dyna-Soar* pilot would command his own flight, to a great degree, control his course, effect his own re-entry. He would be the fore-runner of many space and interplanetary pilots. Like the Astronauts, he would probably be a military man—as most of the great explorers throughout history have been. For the nation needs his skill and his dedication—as it needs the skill and dedication of his leaders.

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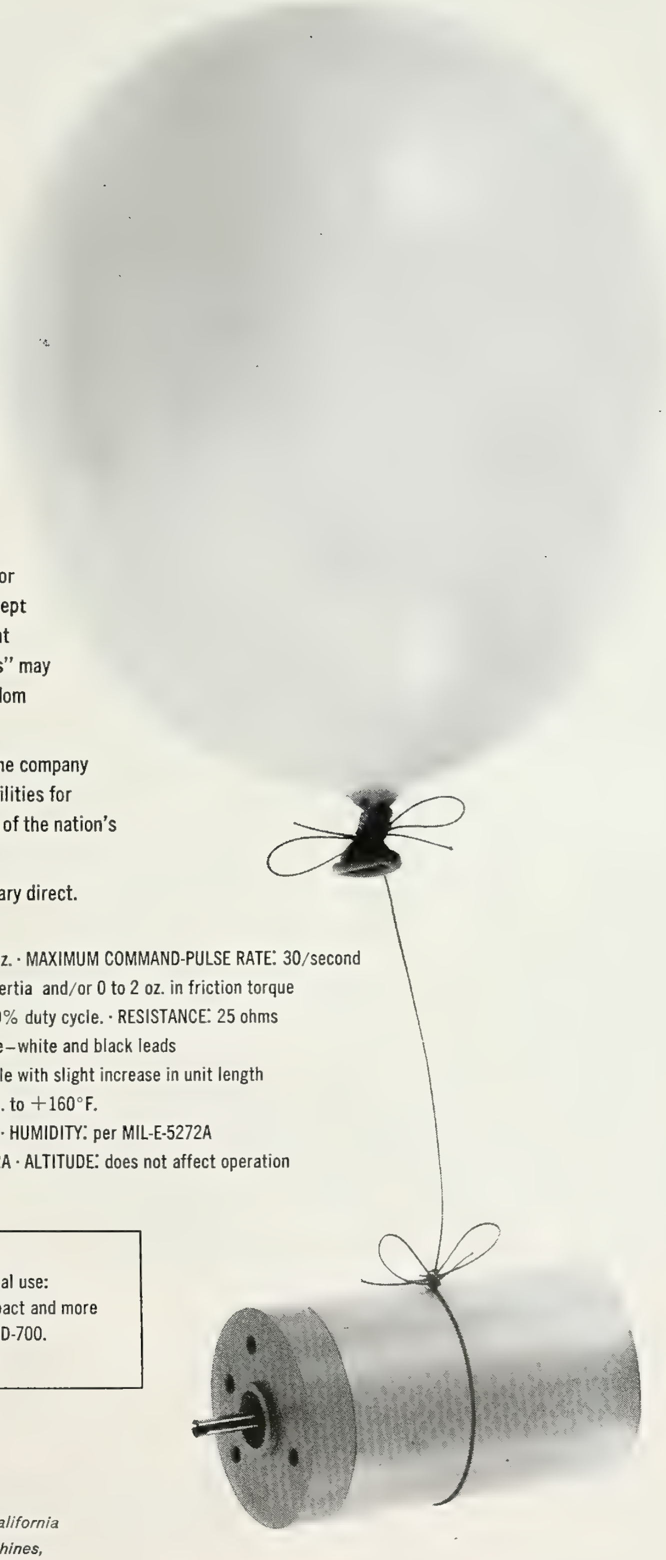

Now from Clary comes a small, lightweight incremental motor with extremely high repetitive accuracy. The unit will accept consecutive command pulses from either of two independent sources in any order, and resulting successive shaft "steps" may be continuously clockwise or counter-clockwise, or any random combination of the two directions.

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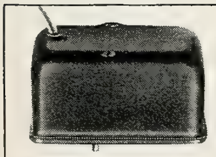

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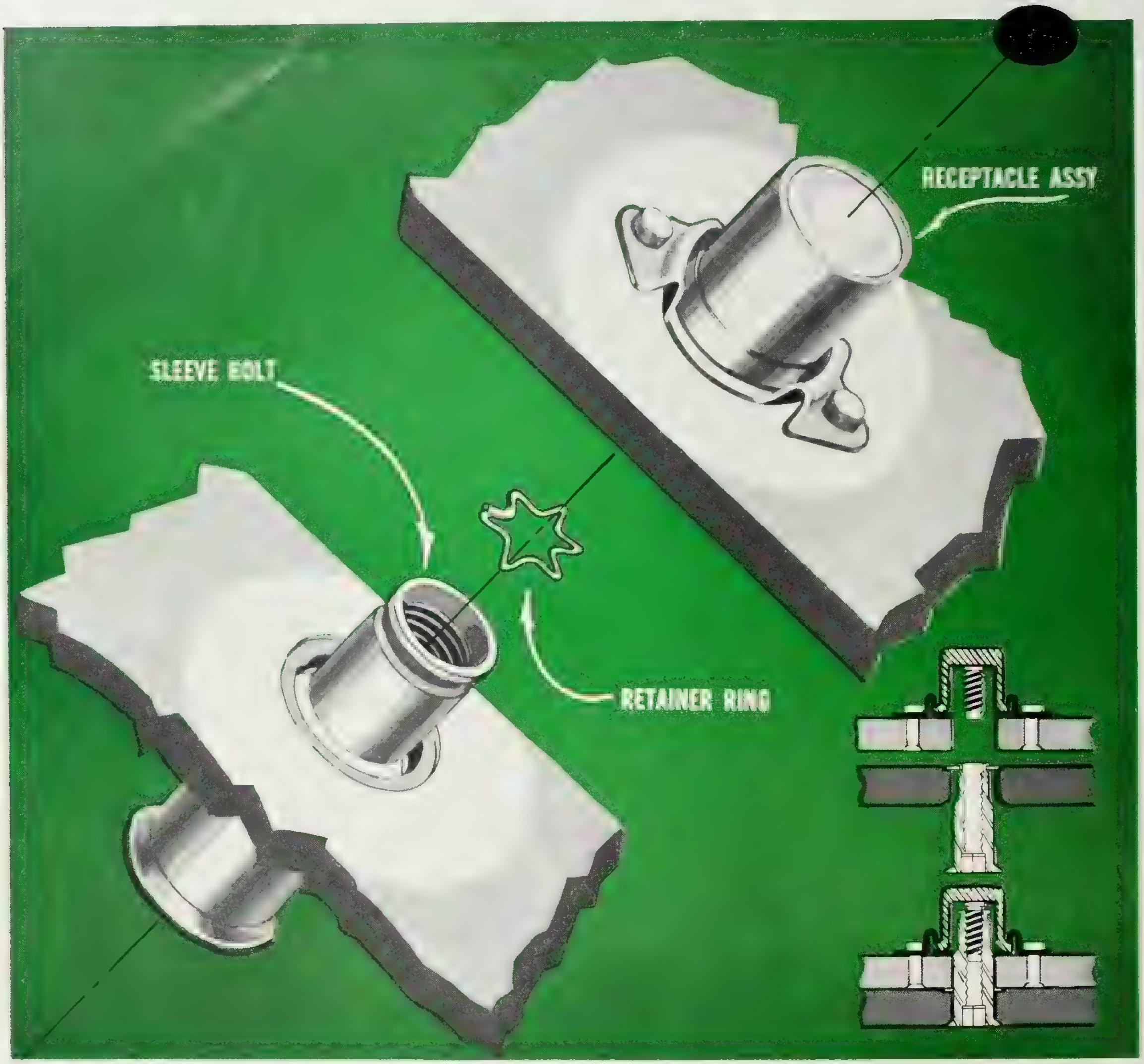

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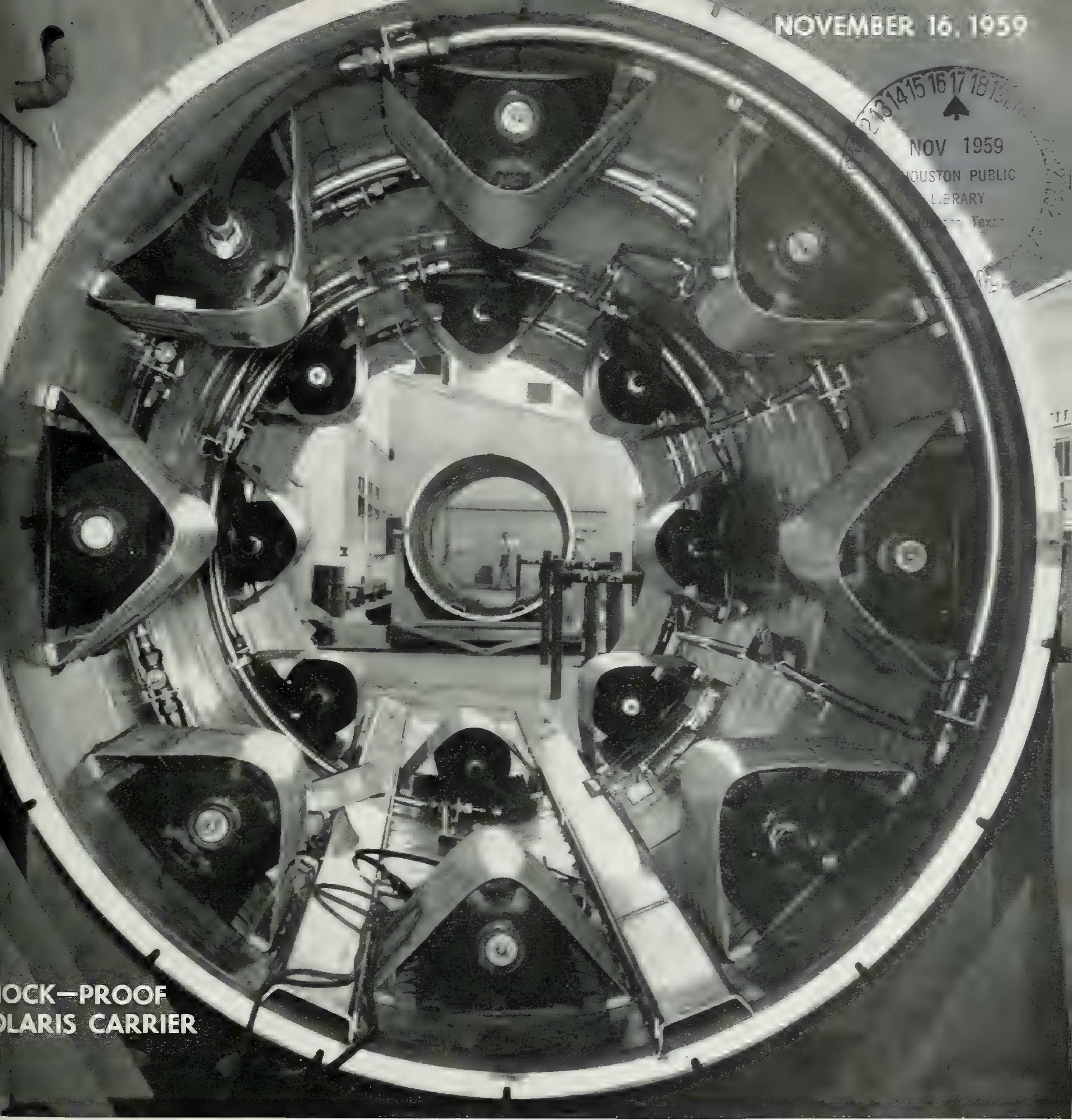

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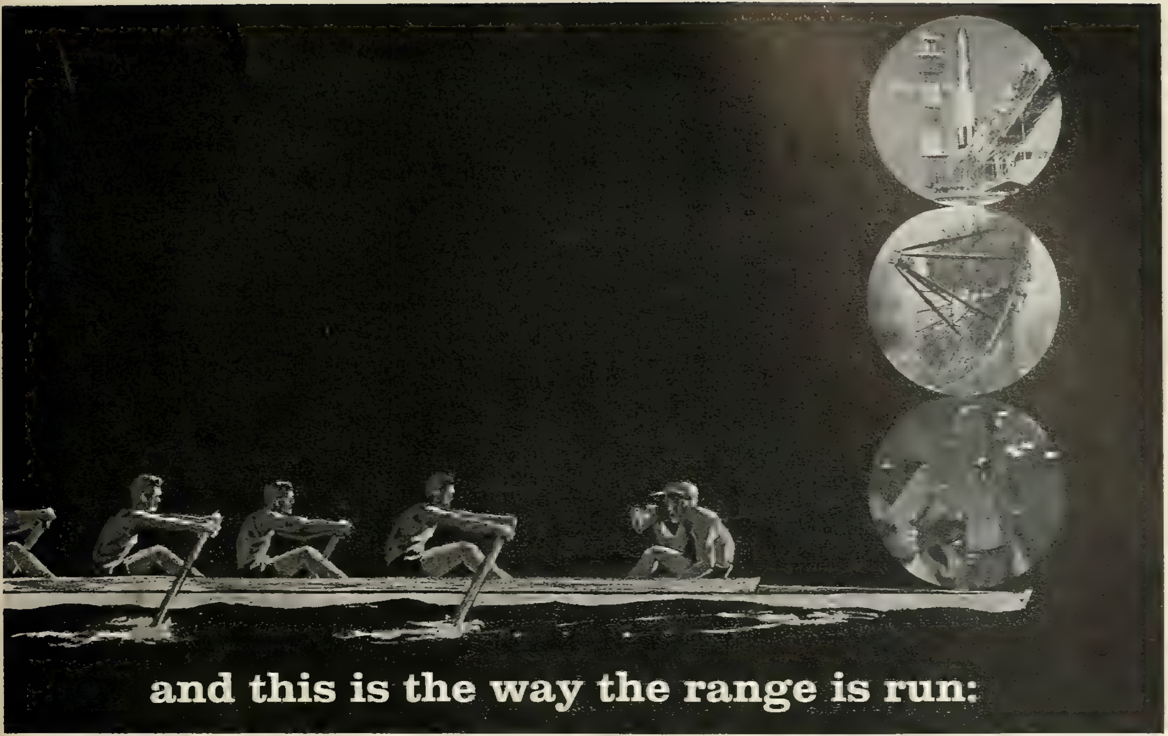
and this is the way the range is run:

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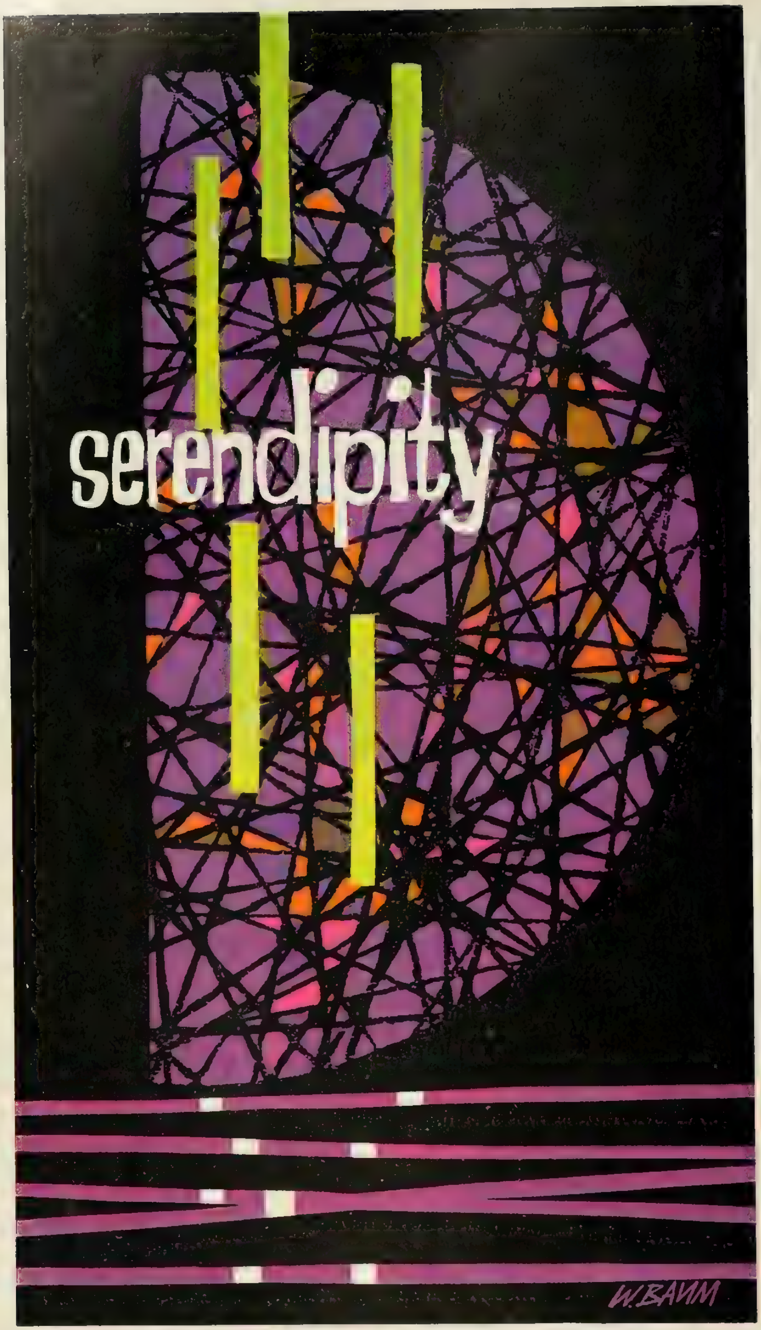

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missiles and rockets

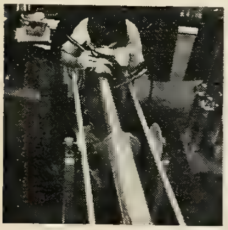
MAGAZINE OF WORLD ASTRONAUTICS

30,800 copies of this issue printed

COVER: Prototype of the air suspension system Goodyear has developed for Lockheed's *Polaris* shock-proof shipping container. Spring efficiency goes up to 90%. (See p. 45.)

MISSILE cruiser queen will be nuclear-powered Long Beach, to be commissioned in March—without *Polaris* facilities. A report on what the Navy would like to do with *Polaris* on surface ships begins on p. 12.

DOUGLAS *Thor* IRBM delivered by MATS to England, is prepared for trip to first of four British bases to be equipped with the missile. A first-hand report on a transatlantic trip with *Thor* starts on p. 16.



FINAL subassembly welding of stainless steel deflector for combustion chamber of Thiokol's packaged Guardian I engine. A report on prepackaged liquid propulsion systems starts on p. 24.

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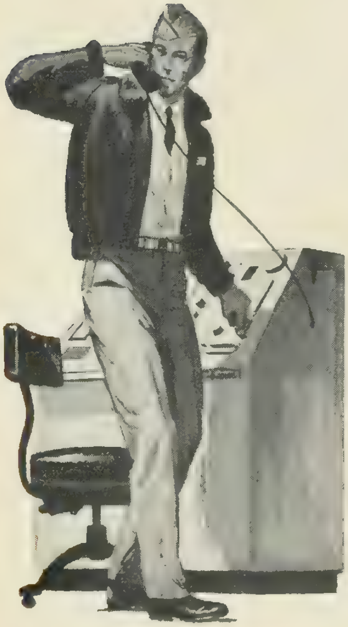
SAC INTERMEDIATE RANGE BALLISTIC MISSILE

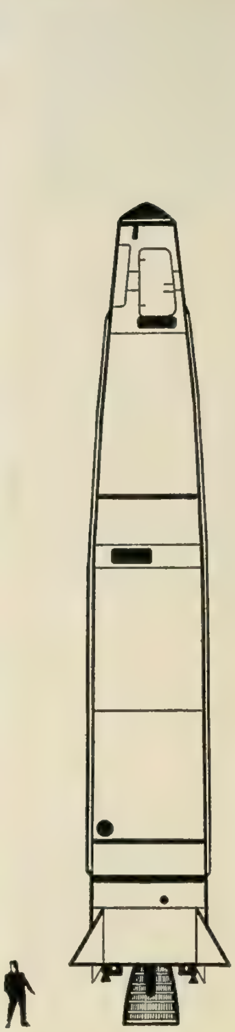


The man:

. . . a launch-control specialist in a *Thor* SAC squadron. His instruments report each automatic step in the launching procedure of the big IRBM. U.S. Air Force and Royal Air Force missilemen are receiving *Thor* training side-by-side . . . have readied and fired these missiles within a 20-minute count-down.

The missions:

. . . are many—because of the Douglas *Thor's* versatility. As a highly mobile weapon with atomic capability, it sternly warns potential enemies against aggression. As a powerful and reliable booster, it is playing a leading role in our exploration of outer space with satellites and probes.



The missile:

. . . can destroy targets as far as 1500 miles away within minutes after hostile action is detected. Douglas *Thor* missiles were the first intermediate range ballistic missiles to be deployed overseas. The United Kingdom has announced the delivery of the first *Thors*, for operation by Royal Air Force personnel.

Depend on **DOUGLAS**

The Nation's Partner in Defense

Washington Countdown

IN THE PENTAGON

A $46-billion budget . . .

for FY 1961 is the asking price the military services are understood to have come up with as the figure closer to their true needs—$5 billion or more higher than the figure the Administration has told them they could have. The $46 billion includes "economies" forced on the services last year.

• • •

The big *Zeus* decision . . .

on whether to go into production is expected about Dec. 1. If the answer is yes, more than $1 billion extra must be added to the FY 1961 budget or taken out of some other programs. Even if the decision is no, another $300 million is expected to remain in the new budget for continued R&D on the big **Western Electric** AICBM.

• • •

First grabs . . .

on the ARPA-Army *Saturn* program are reported to have been given the Air Force. But the Air Force top command passed it up because sufficient funding didn't go along with deal. Other Air Force programs would have to be cut to support it.

• • •

Fast transfers . . .

to the Air Force of ARPA's Project *Samos*—the reconnaissance satellite—and Project *Midas*—the early warning satellite—are now expected. They may come in less than two months.

• • •

But much slower ones . . .

are expected in the case of ARPA's Project *Transit*—the navigation satellite—and Project *Courier*—the communications satellite. Neither may take place for a year or two. But when they do the Navy is still scheduled to get *Transit*; the Army, *Courier*.

• • •

Enter Project *Jaguar* . . .

a powerful air-launched sounding rocket designed for the Air Force. The three-stage solid *Jaguars*—two **Thiokol** *Recruits* and a one-fifth-scale **JPL/Sperry** *Sergeant*—will be launched from B-57's first from Holloman AFB, later from Eglin AFB.

Discoverer VIII . . .

is scheduled to be launched in about a month. ARPA will again try to recover an instrument-crammed biomedical capsule from orbit.

• • •

The Cissler report . . .

on possible duplication on U.S. missile ranges probably will be ready before Christmas rather than Thanksgiving. The report is expected to call for reshuffling of some operations on the multi-million dollar ranges.

ON CAPITOL HILL

A rough going over . . .

is seen in store for the NASA budget when it reaches Congress no matter how much cash is in it.

. . . If the Administration asks for only a slim increase, it will be hit with charges of losing the space race to Russia.

. . . If the Administration asks for a big increase, it will be hit with charges that it admits foot-dragging last year.

• • •

The banned book controversy . . .

involving Gen. Thomas Power's attempt to tell the American people how many missiles and bombers they need to survive the Cold War is far from dead. The House Information Subcommittee is still digging into why publication of the SAC commander's book was stopped.

AT NASA

The Thanksgiving Day Menu . . .

on Nov. 26 is definitely scheduled to include the launching of an *Atlas-Able* carrying a moon-orbiting satellite. The planned *Thor-Able* launching with a sun-orbiting satellite is scheduled for two weeks later. NASA's holiday season package also is rumored to include one other shot still to be identified.

• • •

NASA's adopted children . . .

ABMA and JPL are reported to be advocating that they act as a team to survey new industry proposals submitted to the civilian space agency. The two confide they are not happy with the technical judgment of some NASA officials.

AROUND TOWN

An Air Force tracking station in the Aleutian Islands last week reportedly tracked a Russian missile which traveled a full 4800-mile course. According to the report, the Red ICBM came down north of Midway.

The way to know – An ominous shadow over ocean or wasteland... an unidentified "blip" on a radar scope! A challenge from an airborne AN/APX-7 interrogating unit spurts into the ether. In microseconds a reply identifies the potential marauder as friendly. The absence of such a reply alerts the protective and retaliatory might of the nation.

ENGINEERING BEYOND THE EXPECTED
Packard Bell's reputation as a leading designer and foremost producer of IFF (identification, friend or foe) equipment is indicated by the fact that both the AN/APX-7 and the AN/APX-6, which returns the reply, are products of our Technical Products Division. Advanced development, company-sponsored, has recently produced miniaturized IFF modules which operate up to 200°C.

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Industry Countdown

MANUFACTURING

Upwards of $1 billion . . .

for all phases of the *Titan* ICBM program—including hardened bases—may be sought by the Air Force in the FY 1961 budget. Good share of the money would be for improvements in the bird—**AC Spark Plug's** all-inertial guidance, storable, non-cryogenic propellants, uprating of the first-stage engine, and a bigger diameter second stage—to be phased into later squadrons.

• • •

Bigger second stage . . .

would give **Martin's** basic *Titan* design a capability: 1) for larger payloads and longer striking distance; 2) as a larger second stage for *Saturn*, and 3) as a clustered boost or a second stage for a winged re-entry vehicle such as *Dyna-Soar*.

• • •

Prime contractor "pirating" . . .

issue is now in the hands of DOD's Small Business Industry Advisory Committee. The Senate Small Business Military Procurement Subcommittee has handed a report to the DOD group showing "limited examples" where technical information developed by subcontractors is being improperly utilized by primes and higher tier subs.

• • •

Latest *Polaris* birds . . .

are one-third lighter than original models thanks to reduction in weight of inert parts. For his contribution to the weight-cutting program, E. R. Roberts of **Aerojet-General** won the 1959 Hickman Award.

PROPULSION

High-energy solid fuel . . .

that will be as safe to transport as a barrel of kerosene reportedly is under development at **B. F. Goodrich** plants in Brecksville, Ohio, and Rialto, Calif.

• • •

Extra-high mass ratio . . .

space motor (end of scale 94.95 and above) may be test fired shortly by **Grand Central Rocket.** Burning "Nitrolel" (carboxylated butadiene acrylo nitrile), the engine is designed for upper-stage vehicles—soft lunar landings, deep space probes, satellites.

Process for producing . . .

high-boiling hydrogenated polycyclic hydrocarbon high-energy fuels has been patented by **Monsanto Chemical.**

ASTRIONICS

Flying TV camera . . .

will be used to prove out the **Martin** 700-mile *Pershing*. Miniaturized unit—housed in a capsule which is ejected from missile during flight—photographs warhead to impact point. Developed for ABMA by **RCA** and **Chrysler,** the camera will be used for target damage assessment.

• • •

Tubes and transistors . . .

standardization program is underway by the Navy's BuShips. Rapid technical changes and lack of production uniformity—particularly in semiconductors and transistors led the bureau to develop some standard test procedures aimed at eliminating unnecessary evaluation of parts.

• • •

ABMA has successfully . . .

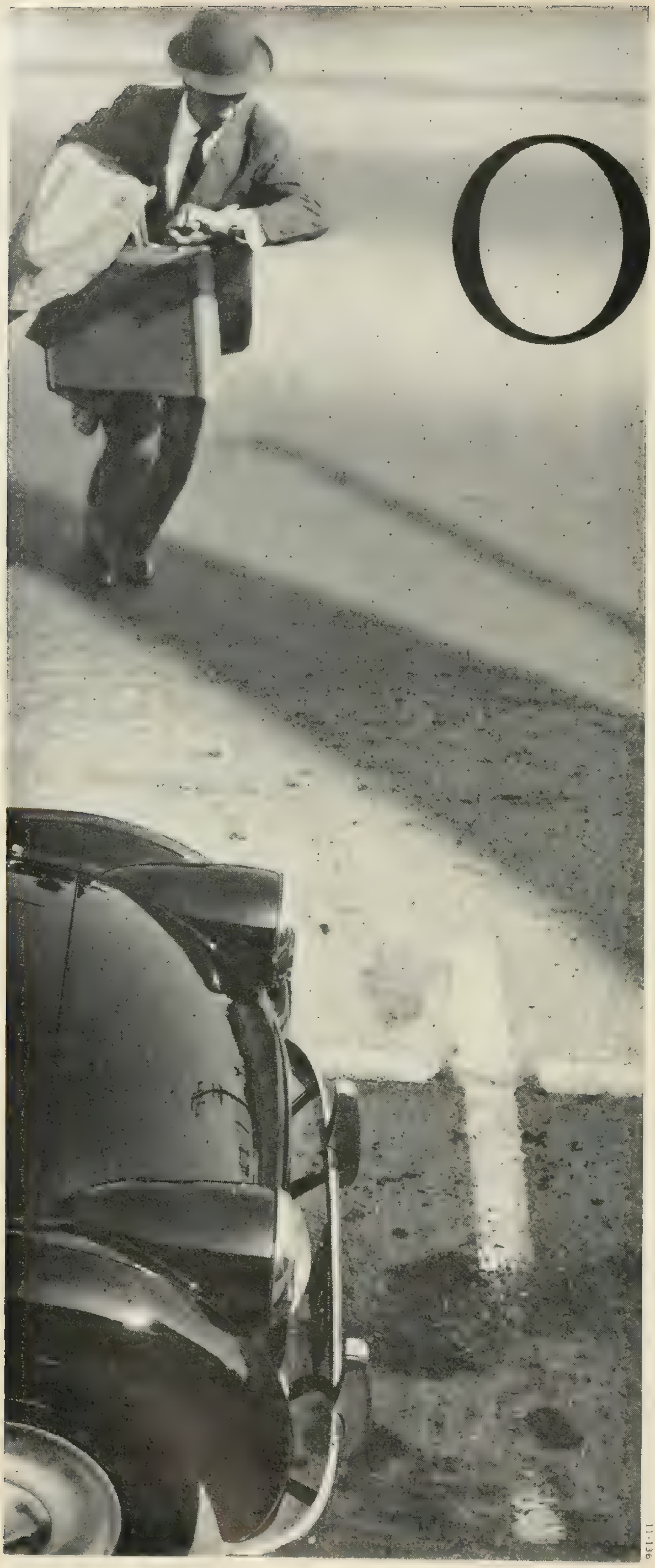
tested production guidance units for a *Jupiter*. Two identical units—one for control and the other for reference—were off-the-shelf and neither was retested or recalibrated after production checkout.

WE HEAR THAT

Nike-Zeus sustainer . . .

will have propellant weight of 7000 pounds . . . Russian rocket engineers are experimenting with hydrogen and fluorine in hopes of using the combination in a 281,000-pound-thrust booster . . . **American Machine & Foundry** reportedly is getting ready to establish a new anti-submarine warfare group . . . New DOD list of top 100 defense contractors will be ready at the end of this month . . . **Rocketdyne** is setting up a new nuclear propulsion engineering subdivision—**Nucleonics** . . . An applied research section to study outer atmospheric conditions affecting space exploration has been created by **Convair** Fort Worth . . .

More About the Missile Week on Page 45.



Operations Research Scientists:

Need time to develop your ideas?

Most scientists engaged in operations research work seem to feel that they cannot do their most productive work when they are constantly fighting unrealistic deadlines.

The operations research programs at System Development Corporation are carefully planned to provide ample time for the development of new ideas that apply to the development of large-scale, computer-based information-processing systems.

The following are just a few examples of the areas in which Operations Research Scientists work at SDC: (1) simulation and operations gaming techniques in problems of control systems; (2) mathematical logic applied to universal computer languages; (3) medical data processing; (4) stochastic modeling of man-machine interactions; (5) logistics; (6) test design for operational computer programs.

Operations Research positions are now open for scientists at several levels of experience. Please send your inquiry to Mr. E. A. Shaw, SDC, 2414 Colorado Avenue, Santa Monica, Calif.

……

"Application of Computer Simulation to Production System Design," a paper by Allen J. Rowe, is available upon request. Send request to Dr. Rowe at SDC.

……

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11-136

Red Breakthrough—Fact or Fiction?

Tass reports Soviet scientists have achieved nearly twice the theoretical top efficiency; reaction of U.S. experts varies widely

by Hal Gettings

LONDON—Thermal efficiencies of 182%, almost twice that theoretically possible, have been reported by Russian scientists. The spectacular—if true—breakthrough was attributed by Tass, official Soviet news agency, to a new thermoelectric device now under research. (Thermoelectricity deals with the phenomena of changing heat directly into electricity, and vise versa.)

The Moscow device reportedly produced in heat form nearly twice as much energy as was put into it in the form of electricity.

Response of U.S. scientists queried by MISSILES AND ROCKETS varied from utter disbelief (". . . the dispatch must have been garbled.") to acceptance of the achievement as not only possible but expected. One English scientist claimed that he had done the same thing eight years ago. At least one patent is in the works in this country for what could prove to be a parallel advancement.

The Tass dispatch claimed, however, that "this wonderful phenomenon never before had been demonstrated experimentally."

• **Simple pump?**—Dr. Stephen Angelo of **Westinghouse,** one of the nation's top authorities on thermoelectricity, is of the opinion that the device could well be no more than a "thermoelectric heat pump." He said it is possible to move a certain number of watts from a lower to a higher temperature—in effect, run a refrigerator backwards—and produce up to twice as much heat as the equivalent electrical power required to operate the device. No violation of thermodynamic laws would be involved.

Others have theorized that the indicated "amplification" might be attributed to a release of part of the nuclear energy within the thermoelectric semiconductor materials. This, however, would involve a change of mass into energy and does not seem particularly logical in this particular instance.

• **Time for reappraisal?**—Another conclusion drawn is that perhaps certain accepted "basic truths" might need to be re-examined in the light of new knowledge. Under the impact of tremendous recent scientific progress, old definitions and limitations may not hold.

It has been apparent for some time that many scientific definitions are in need of clarification, particularly in the fields of energy and conversion. Just how do you measure the inherent energy in a pound of coal, for example? It is well known that a handful of material contains enough energy to drive a ship for thousands of miles. To date, the only method of unlocking a significant amount of this energy has been through nuclear reaction. The common method of burning a fuel releases only a fraction of its potential. Which yardstick do you use?

By the same token, the thermoelectric material undoubtedly contains energy put into it by processing and manufacture. Perhaps some of this energy could be released to provide a gain in efficiency. Experiments are being conducted along similar lines in this country to investigate improving the "figure of merit" of thermoelectric materials.

• **Not taken lightly**—In any case, the scientific consensus is that such Russian announcements almost invariably have proved to be factual. With the possible exception of claims as to the nationality of discoverers of certain basic scientific principles, few, if any, authoritative Soviet technical statements have been disproved.

Russia is conceded to be ahead of any other country in thermoelectric research. They produced several years ago practical low-cost thermoelectric generators to operate small radios and refrigerators for areas outside conventional power sources. Their rapid progress in this field no doubt gave impetus to recent U.S. emphasis on similar research. It would seem logical to evaluate this new advancement on the basis of what its potential contribution could really mean, rather than to dismiss it as merely a juggling of figures.

Mishap To Delay X-15 Plans

WASHINGTON—It appears that man's first excursion into space aboard a rocket plane will be slowed as a result of the recent accident to the second *X-15* on Nov. 5. It also will force a rearrangement of plans which called for the turnover of plane Number 1 to NASA.

The big question to be solved now is what caused a fuselage crack at what the manufacturer calls an "attachment point." Investigators still have to determine the relationship, if any, between the crack and the explosion which took place in the upper compartment of the lower rocket engine. Indications are that the fuselage damage was not caused on landing.

It's estimated that if there is no more damage than the first investigation disclosed, plane Number 2 could be repaired in six to eight weeks. However, the basic question of why the structural damage occurred to the fuselage and how the explosion and fire started may take longer. This will automatically postpone completion of tests which were to lead to flights out of the atmosphere.

Indications are that the scientists who have been heavily involved in the program will hang out the "go slow sign" to make sure that pilots' lives are not unnecessarily sacrificed and the $100-million program is not washed out. As one man put it, "time isn't that important."

'Second Blow' in Total War . . .

Navy Pushes for Big Fleet of *Polaris*

Urges eventual deployment of hundreds of IRBM's aboard some 24 cruisers as supplement to subs and SAC; new Polaris surface force might include battleships

SURFACE launching of dummy *Polaris* from tube in deck of Test Ship Norton Sound. Ship's list is deliberate.

by James Baar

WASHINGTON—The Navy is pushing for deployment of hundreds of *Polarises* aboard surface warships to give America's retaliatory forces a mobile-based "second blow."

The proposal eventually would call for a fleet of more than two dozen *Polaris* cruisers that would serve as a supplemental or alternate force to the Navy's *Polaris* submarine fleet and the Air Force's SAC.

The Navy contends such a force would:

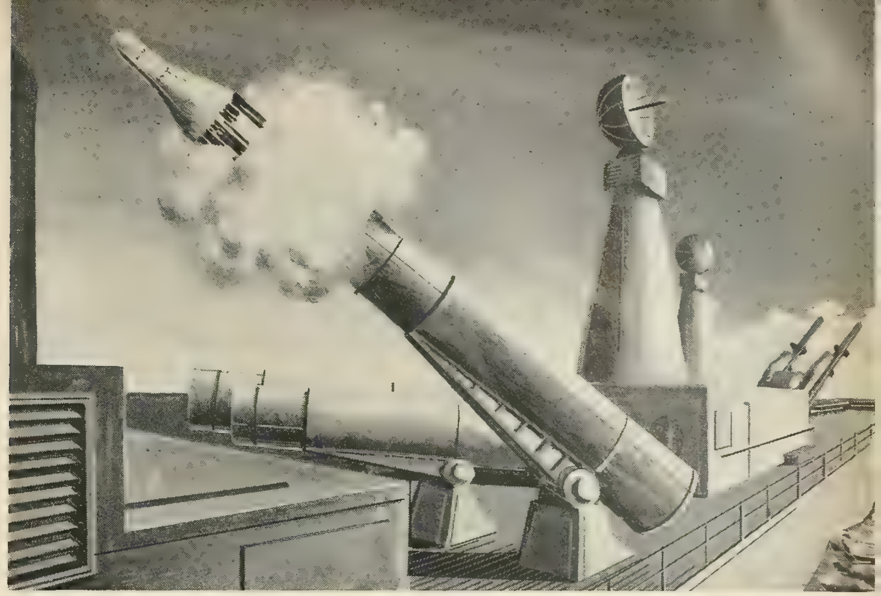
- Greatly increase the difficulty of any attempt by Russia to deliver a surprise knock-out blow to U.S. retaliatory power thereby increasing American deterrent power.
- Rapidly give the United States a build-up of mobile missile bases that would help defend the nation during the fast-approaching years of the Missile Gap.
- Provide a reservoir of great striking power that could be used to conclude a war that started with an all-out exchange of nuclear weapons.

This is the heart of the Navy *Polaris* cruiser plan which has been shelved at least temporarily by the Defense Department since early this year.

Under the plan, the Navy would have had at least one *Polaris*-armed cruiser at sea in 1960 or by mid 1961 at the latest along with the one *Polaris* submarine scheduled to be operational. The cruiser would have been the nuclear-powered Long Beach.

The Navy had ordered that *Polaris*

Cruisers



ALTERNATE method of launching *Polaris* from cruiser is shown in an artist's conception. It might be used on nuclear-powered Long Beach.

launching tubes be installed in the big cruiser while it was under construction at the **Bethlehem Steel Shipyard** at Quincy, Mass. But the Defense Department pulled back the order to review it.

The installation of the tubes and launching equipment will take an extra eight months if the Long Beach is sent to sea without them and is returned to the yards later to be equipped with them.

Speed and availability are two of the Navy's big arguments for putting *Polaris* on surface ships. It contends the plan would greatly increase the rapidity of a build-up of mobile and dispersed U.S. retaliatory forces.

Hardened and mobilized **Boeing** *Minutemen* ICBM's are not expected to begin entering SAC's retaliatory arsenal until about 1962. Meantime, the major U.S. retaliatory force will continue to be manned bombers—many of which may have to be kept on constant airborne alert as Russia's ICBM stockpile rapidly increases—or run the risk of being caught on the ground. The cost of maintaining an airborne alert is expected to run from one to several billion dollars a year.

It is against this background that Navy officials have argued for beginning a *Polaris* cruiser problem as quickly as possible.

However, not a dime for deployment of the **Lockheed** IRBM's on cruisers is expected to show up in the FY 1961 budget. And the Long Beach will be commissioned in March without the launching facilities for them.

Any decision that would authorize deployment of *Polarises* on cruisers isn't expected now until the fall of 1960. Nor are the chances too good that the decision at that time will be in favor of the plan.

Money and the Administration's tight-budget policies are the principal obstacles.

The Navy is having great difficulty in securing funds to push construction of *Polaris* submarines let alone the deployment of *Polarises* on surface ships.

The new budget is expected to provide funds for only three more of the missile-launching submarines instead of the nine that the Navy has advocated. And the Navy considers the *Polaris* cruiser a supplement—not a substitute—for the submarine.

- **Comparatively cheap**—It feels that more funds for both should be added to its budget.

The cost of installing *Polarises* on cruisers is comparatively cheap as modern weapon systems go. All launching and other missile support equipment for 16 *Polarises* can be installed on a cruiser for about $40 million. The cost for eight *Polarises* is about $20 million.

The U.S. missile cruiser fleet—operational and under construction—and its present and scheduled armament. The commissioning dates listed are current estimates.

Cruiser	Missiles	Status
BOSTON	TERRIER	Optl.
CANBERRA	TERRIER	Optl.
GALVESTON	TALOS	Optl.
PROVIDENCE	TERRIER	1/60
LITTLE ROCK	TALOS	3/60
LONG BEACH (nuclear)	TALOS-TERRIER-ASROC	3/60
SPRINGFIELD	TERRIER	3/60
TOPEKA	TERRIER	4/60
OKLAHOMA CITY	TALOS	5/60
ALBANY	TALOS-TARTAR-ASROC	7/61
CHICAGO	TALOS-TARTAR-ASROC	10/61
COLUMBUS	TALOS-TARTAR-ASROC	12/61

These figures are in addition to the approximate $100-million cost for conversion of a cruiser to a missile cruiser. If *Polarises* are installed after the conversion, the cost goes up about 25%.

Initially, Navy officials thought in terms of eight *Polaris* cruisers. That would put the total price tag at about $250 million plus another $400 million for the extra conversions of ships—some of which are planned anyway.

The *Polaris* cruisers would add a new arm to a growing missile Navy that already includes some 80 ships that are operational, authorized or under construction.

The queen of this missile fleet is the 14,000-ton Long Beach. In essence, the $250 million ship is a floating missile base capable of cutting through the world's oceans at about 30 knots.

Unlike the first group of converted missile cruisers, the Long Beach will not carry a gun. Instead, her more than 700-foot deck will be dotted with missile launchers.

Here is her presently-planned armament:

- *Talos*—A twin-rail stern launcher built by the Naval Weapons Plant will fire the more than 65-mile range **Bendix** missiles. The nuclear-tipped *Taloses* can be used against missile-launching aircraft or for long-range heavy bombardment. The Long Beach will carry probably more than four dozen.
- *Terrier*—Two twin-rail **Northern Ordnance** launchers will fire the 10-mile-range **Convair** missiles from the bow and forward area. The Long Beach probably will carry more than 100 *Terriers*. The surface-to-air missiles carry high explosive warheads.

MISSILE CRUISER queen, the nuclear-powered Long Beach, carries (stern to bow) *Taloses, Polarises, Asrocs* **and** *Terriers* **in this graphic artist's conception.**

- *Asroc*—A **Universal Match** launcher almost amidships will fire the new **Minneapolis-Honeywell** anti-sub missiles.
- Torpedoes—Midship port and starboard tubes built by the Naval Operating Plant of Louisville will launch **GE** anti-sub Mark 44 torpedoes.

The *Taloses* will be fed semi-automatically to the launcher by the huge **GE** launching system that stores the missiles ready for action in trays. The *Terriers* will be fed to their launchers by the Northern Ordnance "coke-bottle" launching system that stores the missiles around revolving drums.

The Long Beach magazines that house the *Terrier* and *Talos* launching systems are more than 30 feet deep. They take up much of the stern and forward quarters of the ship.

The *Asrocs* will be stored and fired from the box-like *Asroc* launcher.

Polarises—if installed on the Long Beach—would probably be launched from tubes elevated from a horizontal position on the deck. Three of the 28-foot missiles could be stored in the tubes: five more would be stored nearby.

The alternate method for launching *Polarises* from cruisers is from eight or 16 tubes constructed upright inside the ship's hull. The easiest way to do this is to remove turrets and install the tubes in their place. The tubes will be installed at an angle to prevent any missiles from falling back on the deck.

Installation of tubes below or on the deck is considered an eight-month job as long as space and weight have been taken into consideration in construction or conversion of the ship.

So far, space and weight for *Polarises* are being allowed for on the Long Beach and three heavy cruisers undergoing conversion to missile ships: the Albany, Chicago and Columbus. The last three are scheduled to be operational in late 1961.

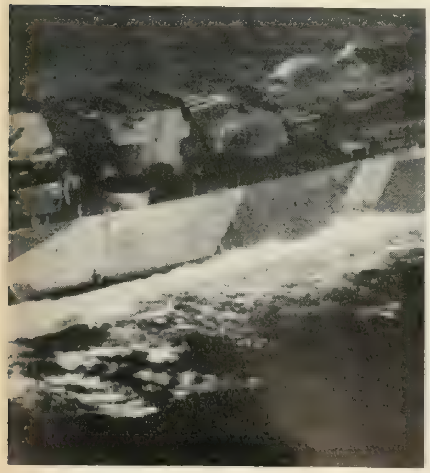
The Navy's eight other missile cruisers—three operational and five scheduled to be by mid-1960—have not been constructed with *Polaris* in mind. Their armament is *Terrier, Talos* or *Talos* plus the new **Convair** *Tartar*.

However, the Navy has six other operational cruisers, 31 mothballed cruisers and 10 mothballed battleships to draw from for deployment of *Polarises.* Besides these, the Navy also has considered deployment of *Polarises* aboard its proposed swift new auxiliary ships such as the AOE's—the combined oiler and ammunition ships.

All of these would provide what the Navy wants in a surface IRBM launching platform: speed, mobility and dispersion. But there is no question that the cruiser is looked on as the most likely ship for the job—particularly because of its ability to fill such a wide variety of missions.

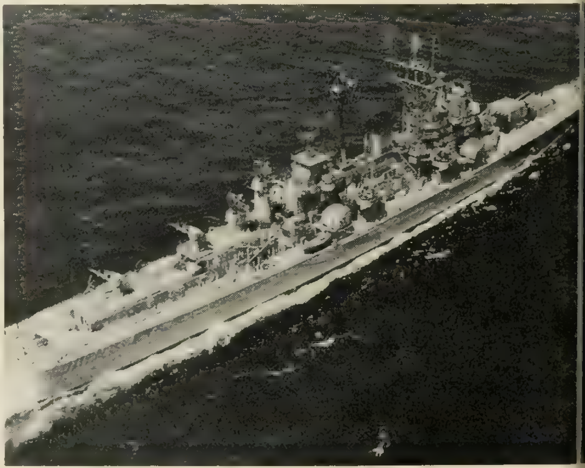
As the partly-completed Long Beach lies in her pier at Quincy, you can look down through the deck at the great missile-launching systems and sense the ship's power.

But many Navy officers feel the Long Beach is far more than just a powerful ship. They see it in the years ahead as the possible leader of a great armada that alone might hold the balance of power in an H-bomb-smashed world.



LEFT—Before conversion the cruiser Springfield carries two conventional stern turrets.

RIGHT—After conversion the missile cruiser Boston boasts two *Terrier* **launchers astern.**



soviet affairs

by M/R Staff
from Official Translations

Planet-based Radios for Guidance

A Russian scientist has stated that radio navigation for space ships will probably be effected by establishing radio transmitters on the plants of destination or on their satellites.

V. I. Siforov, Chairman of the Central Board of the Popov Scientific Society of Radio Engineering and Electric Communications, and a Corresponding Member of the Academy of Sciences, USSR, predicted in a recent issue of *Moscow News* that the pilot of a future interplanetary ship will tune into a particular waveband—the rest will be done automatically as in modern aviation.

Siforov believes that, in contrast to terrestrial conditions radio navigation transmitting stations will not be motionless but will move along a complex path. Yet the positions of the radio beacons will be known to the astronauts, and their complex courses will be plotted in the course of computing the whereabouts of the spaceship.

Superior Magnetometer?

A Soviet technical paper claims that a D. D. Voyekov has designed an accurate magnetometer employing the Hall effect that is "superior to similar non-Soviet meters."

Basic error is given as ±1.5% +1 gauss in the 100-16,000 gauss range. Temperature range is –30° to +50°C, the temperature influence error not more than ±0.3% per 10°C.

The magnetic pickup of the magnetometer is made from n-type germanium with a specific resistance of 2-3 chm/cm. Dimension of pickup, 2.7 x 2.7 x 0.4 mm^3; sensitivity, approximately 10 microvolts per gauss. Temperature control for increased accuracy is achieved by placing the Hall pickup inside a small brass container equipped with a heating element and a small transistor.

The pickup is heat-insulated from the container's wall but the thermistor has a firm, heat-conduction contact with the element and container. Thus, while variations in the container's temperature are applied directly to the thermistor, they reach the pickup only after considerable delay.

Periodic temperature variations in the ±1.5°C range cannot influence the pickup, since the entire cycle of temperature of the unit is maintained within an accuracy of ±0.1° to ±0.25° C. The NMN-3 is recommended for both laboratory and industrial use. (*Pribory i tekhnika eksperimenta*, No. 4, 1959).

New Research Center

The Kirghiz Academy of Sciences has begun construction of a scientific research center 128 kilometers southwest of Frunze which will be used to study cosmic radiation, radio engineering, high mountain physiology, and astrobotany.

The station, according to the Bucharest, Rumania, publication *"Elore,"* (May 23, 1959) will be on a 10,000-ft. mountain and contain a meteorological station, several laboratories, power plants, apartment houses, clubs, stores and repair shops.

Polyethylene Lag Hit

Y. Krein, writing in *Promyshlenno-ekonomicheskaya Gazeta* (Oct. 4, 1959) claims that Soviet scientific research institutes have been "dragging their feet" for three years in the production of polyethylene at low pressure.

Initially the plan was to build a pilot plant to obtain data and experience for production on a commercial scale in 1960. However, the experimental facilities have not been finished because of defective specifications.

The Soviet writer also states that because of confusion over what agency was responsible, no industry has been assigned to make the gas blowers and high-pressure ventilators, and that the nine horizontal centrifugal machines with fourfold rinsing for the polymerization shop have not been produced.

Radiation Experiment

A special instrument was installed in *Sputnik III* for registering only those electrons with energies of tens of kev, it was reported in a recent Russian technical paper.

Dr. Albert Parry, professor of Russian at Colgate University, has long contributed a monthly column on Soviet Affairs to M/R. Because of the increasing interest in things Russian, we now plan to supplement this coverage wtih more frequent material emanating from the USSR, translated by official sources in this country, and compiled by the M/R editors.

The effect of X-rays was excluded by means of fluorescent screens and aluminum foils. Monochromatic electron fluxes were reduced to monochromatic electrons. The reduced energy of the electrons was called "equivalent" energy.

According to the paper, electrons carrying energies of about 10 kev were found at altitudes from 470 to 1880 km above sea level. The intensity of the electrons is higher in the daytime than at night.

Their flux can form different angles with the geomagnetic lines of force and the direction of flux is less than a certain value, particles with low energy are able to penetrate deep into the earth's atmosphere. *(Izvestiya AN SSSR. Seriya geofizicheskaya,* No. 8, 1959.)

Atomic Battery Research

Corresponding Member of the Soviet Academy of Sciences Vladmir Siforov has predicted that Russian space flights to Mars and Venus will be powered by atomic batteries.

The Soviet Union is doing extensive research on semiconductor-operated atomic batteries, according to Siforov, and regards Strontium 90 as the most suitable radioactive material because it can produce a large number of secondary electrons (up to 200,000 per primary electron) in a semiconductor layer.

However, the low magnitude of electric currents and voltages produced by the electron emission requires that numerous primary atomic cells be employed simultaneously to obtain currents and voltages strong enough to run space electronic equipment. *(Norddeutsche Neueste Nachrichten,* Rostock, Germany. Sept. 30, 1959.)

Pulse-Amplitude Analyzer

The Physical Institute of the Armenian Academy of Sciences has developed a pulse-amplitude analyzer in which use is made of logarithmic conversion of pulse amplitudes into duration as a result of which pulses in all the channels are measured with the same relative accuracy.

The Soviet journal *Atomnaya Energiya* (Sept., 1959) stated that the analyzer is intended for use with a 5-strata proportional counter when studying cosmic rays.

M/R editor is first correspondent to fly Atlantic with big ballistic missiles; guidance units pose trickiest problem of in-flight maintenance

Thors Are Airlifted Gentl

by Donald E. Perry

LONDON—Transporting the *Thor* IRBM and its component parts by C-124 between the U.S. and England is an assignment that MATS must approach with the delicacy of handling eggs or dealing with a temperamental woman.

The C-124 crews have problems and MATS has largely had to write its own standard operating procedures along the way. Although crews run into electrical trouble with some 30% of components shipped, the record of Eastern Transport Air Force's 1607 Air Transport Wing in hauling the big ballistic missiles is impressive.

These and many other things I found out when I became the first newsman to ride one of the C-124 *Thor* carriers between Dover AFB, Delaware, and Lakenheath RAF Station, England, where the big birds are unloaded.

Most often shipment of *Thor* and components is made on a six-hour lead time. Add to this a noise abatement program at Santa Monica (when the C-124's can take off only between 7 A.M. and 8 P.M.) and the inability of the Airheads in Britain to receive shipments except during normal working hours, and you have one of the stickest logistics problems imaginable.

- **Expensive operation**—This is also reflected in operating costs. Airlift of *Thor* comes under the special mission category. Example: For one airplane to fly to the coast from Dover AFB and pick up a *Thor* and transport it to the United Kingdom costs $33,000.

Some 40% of MATS' flying hours are devoted to special missions. The biggest single item is missiles and their support equipment which take up more than 50% of that total.

The big rub is that in special mission operations where there are no regular MATS supply channels the "in commission airplane hour" may sometimes be double the cost of the flying hour, which averages $513 for the C-124.

There are no exact figures on costs to date for shipment of *Thor* and components to the United Kingdom, I was told. However, it can be generally assumed that for every aircraft that carries the bird, at least 10 more are required for component parts. Between two and three aircraft leave Dover on a weekly average usually grossing out at maximum of 185,000 pounds, so in the more than one year's operation of *Thor* airlift, one heck of a lot of tonnage figure can be imagined.

Normal routing from Dover is to Harmon Air Force Base, Newfoundland, with load factor determining whether the flight can be made direct to Britain or via the Azores for refueling.

SAFELY DELIVERED in England, a Douglas *Thor* is readied for trip from airhead at Lakenheath RAF Station to Feltwell, first of four British bases to get the missile.

as Eggs

Engineering-wise, MATS personnel largely has had to rely on contract personnel for in-flight maintenance and servicing of *Thor* components and subassemblies. Trickiest things are guidance units.

- **Protecting gyros**—The **AC Spark Plug** Inertial Measurement System contains two major subassemblies; the inertial platform contains a series of gyros suspended in Floralube, a flotation medium requiring temperature control within a specific range.

To achieve this temperature control an electronic package is installed on the forward face of the shipping pallet. If the generating system should have more than a five-minute power-off, there could be irreparable damage to the AC Spark Plug unit, or—at the least—it could become necessary to recalibrate the individual gyros, conservatively estimated to cost $5000 each.

- **More precautions**—To protect the empty missile tank sections during air transport, **Douglas** recommended a rate of descent between 500 and 1000 feet per minute within the 0 through 20,000-foot altitude range. Maximum rate of descent cannot exceed 2000 feet per minute because of the thin-skinned tankage shell.

EASTAF's 1607 Air Transport Wing has a set of precautions to observe while transporting the inertial system. After starting engines, the outboards must be maintained at 1200 RPM's while taxiing and while waiting for take-off, even though aircraft braking is necessary.

Pilots must wait for level-off before checking the C-124's power operations (pitot heaters, landing lights, etc.). Testing must be restricted to one operation at a time. This is to prevent starving the guidance system heater circuits.

On landing there is a battery backup which automatically provides the required heat control to the guidance system, until such time as the plane is plugged into ground power.

The power requirement is 28V DC 75 Amps—50 continuous, derived from the C-124 power supply.

- **Going through channels**—Here's the chain of command for airlifting *Thor*. Ballistic Missiles Division Transportation is under Air Materiel Command. Transportation determines airlift requirements. AMC Headquarters goes through Headquarters AF which transmits requirements to Headquarters MATS. MATS gets a monthly tonnage requirement and in turn gives it to Eastern Air Transport Air Force. EASTAF then gives the 1607th Air Transport Wing the yeoman's task of executing requirements.

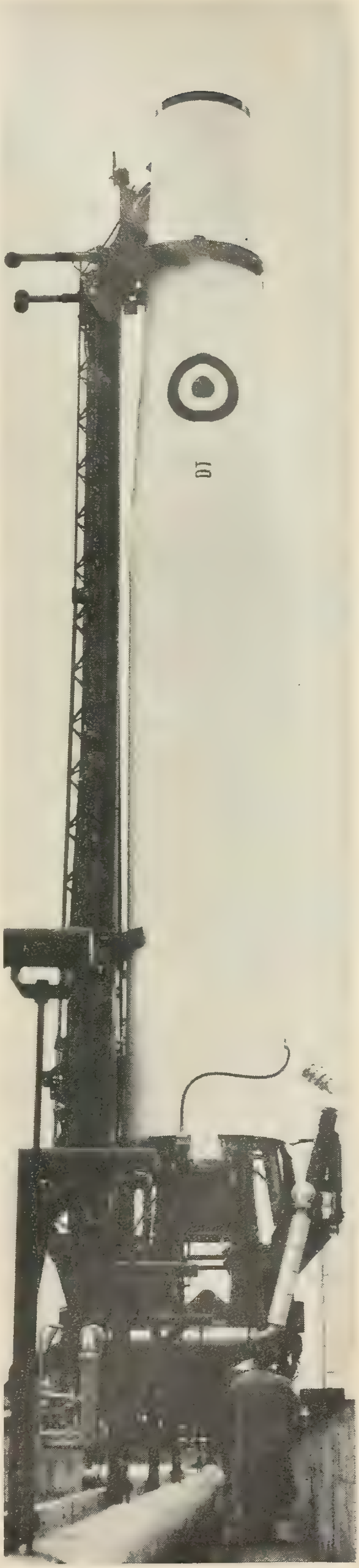
Next Spring, EASTAF will get delivery of the first C-133B—the only air cargo transport in the world capable of carrying the ICBM *Atlas*. The Cargomaster can carry more than 26 tons some 4000 miles at an average speed of 323 MPH. The aircraft features clam-shell doors which open in four directions to allow the huge *Atlas* aboard.

By that time, however, England's IRBM program will be virtually completed.

Feltwell base became missile-equipped early in July. Helmswell was expected to be operational this November, Driffield by December, and a fourth, unnamed base before next July.

Each base (M/R, July 27, p. 11) is of squadron strength—15 missiles. Each base consists of a main site and four satellite sites, each with three missiles. Maintenance and housekeeping facilities and personnel are at the main site. Main site and each satellite are separated by about 20 miles.

But after *Thor* will come *Jupiter* for Italy. Ground work has been laid and MATS—while not envisioning a "snap"-type task—considers that operating procedures are pretty well pat and the *Jupiter* job should be much easier.



Thor **NOW BEARING British bullseye markings, is raised into launching position. Each base will have 15 birds.**

$60,000,000 bargain? . . .

Polar Launch Site Urged in Canada

Experts point to advantages which would come with building a launching facility at Moosonee—chiefly reduction of radiation hazards

Editors Note: This report on the possibilities of a polar launching site in Canada was prepared for M/R by two Canadian scientists, formerly with the Canadian Government.

OTTAWA—A polar orbit launching site with a range of 1800 to 2500 nautical miles can be built in Canada for only $60 million.

It would have significant advantages over the present polar launching site at Point Mugu, Calif., and over most of the other sites in the world under consideration. A major advantage of a Canadian site—at Moosonee in Ontario—would be the great reduction of the radiation hazards to manned flight; the Van Allen radiation belts diminish to insignificant size in northern regions, and do not exist in the upper polar regions.

For logistic reasons, the rangehead where the launching facilities will be located must be near a railway center, seaport, large airport or a combination of these. It should also be near the industrial centers of Eastern Canada which would supply most of the equipment for a primarily Canadian venture.

The range proper should be a corridor roughly 2500 miles long and 50 miles wide, with little or no population. At intervals of 100-200 miles along the range, interrogation, monitoring and control stations will be situated, and these should have relatively easy access.

They should also be close to the sea or on an island; supply to inland stations in the Sub-Arctic is difficult and extremely expensive, since most equipment has to be airlifted. Launchings will be directed north, away from the populous United States and the equatorial zone, where the radiation layers are so intense.

• **Screening the sites**—A comprehensive map of Canada shows a number of places that might well serve as the site of the rangehead; four that look promising are Moosonee, Churchill and Lynn Lake in Manitoba, and Shefferville, Quebec. There are others, such as Canada's northern railroad centers on the Athabaska and Peace Rivers and at Dawson Creek, but they are all south of relatively populous settlements which might be endangered by falling booster motors and misdirected rockets—and in any case the length of the ranges is too short to be of real interest.

In the case of Shefferville, transportation is necessarily by boat and then rail—a serious disadvantage. In addition, the central part of the range would extend over Frobisher, which might again lead to population hazards. A thousand miles downrange from Shefferville the range passes into Baffin Bay and out of Canadian control.

At Lynn Lake, many of the prospective monitoring posts would have to be inland, and hence difficult and expensive to maintain. Besides, a range from Churchill or Moosonee provides a longer path over sovereign territory than Lynn Lake or Shefferville.

There remains Churchill, which has received much publicity because of rocket firings there during the International Geophysical Year, and Moosonee, which is being heavily developed with an eye to making it Ontario's first salt water port.

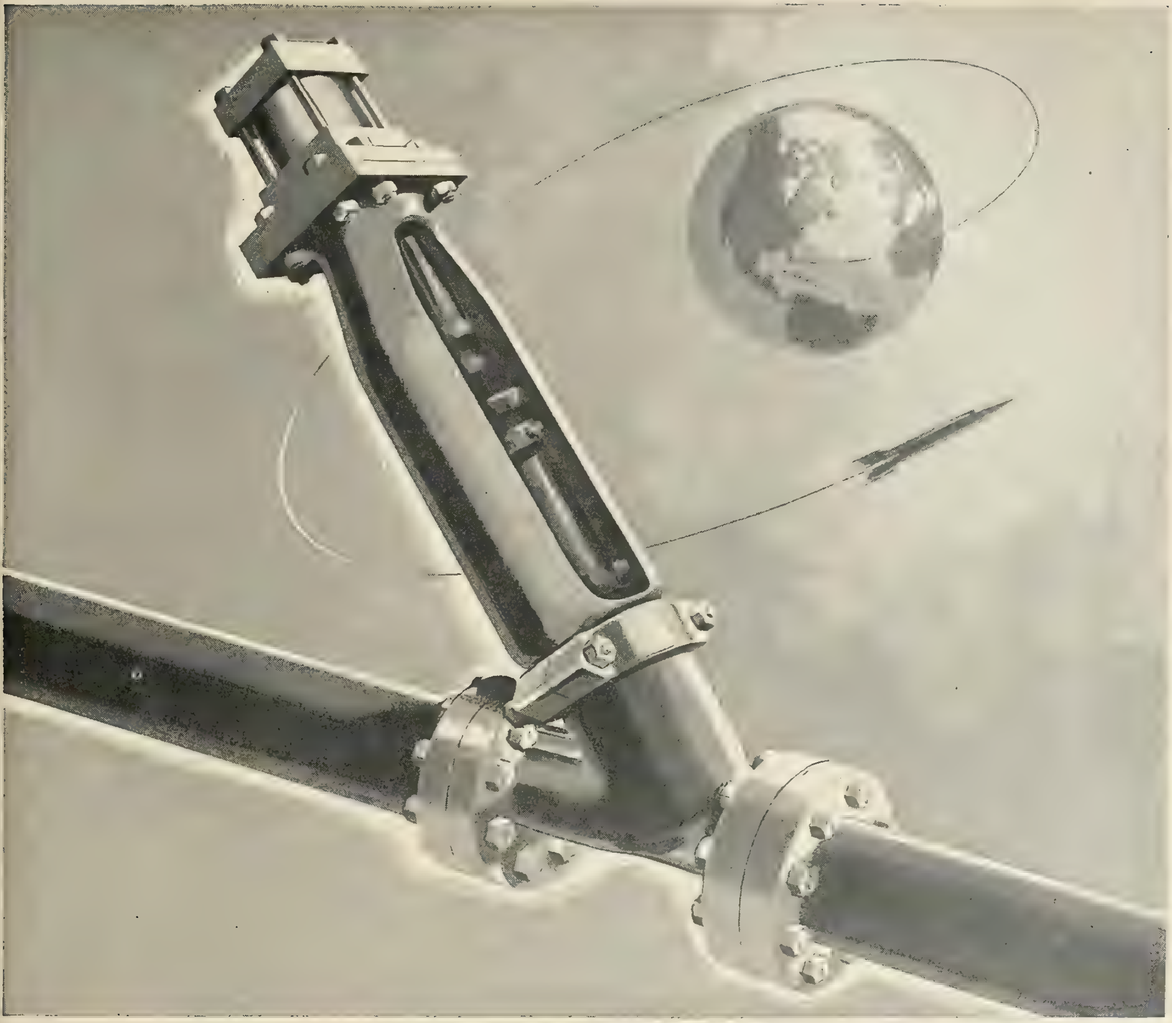
In comparing Moosonee and Churchill, it is necessary to consider a number of factors. Of primary importance is the cost of establishing launching facilities, and here transportation plays a considerable role. Both sites can be served about three months of the year by sea. Churchill is an established seaport while Moosonee is not; nevertheless the cost of establishing harbor facilities at Moosonee would not be charged against rocket site development cost, if present proposals to create a commercial port there go through—as appears very likely.

• **Air and rail connections**—The Ontario government has set aside $5 million to convert Moosonee into a salt water port. In addition, Col. C. E. Reynolds, chairman of the Ontario Northland Transportation Commission, has indicated that an airstrip can be built at Moosonee. Tests have been indicated that gravel to be dredged from shoals in the Moose River would be ideally suited for a base layer for the proposed air strip.

At present, Moosonee has only a private airstrip, used by Austin Airways Limited. According to Austin, the soil is unsuitable for a good airstrip, consisting of one or two feet of overburden on top of clay.

Churchill has a good airfield, which can be used throughout the year, except for a few days during spring break-up. Large aircraft such as the C-133 Cargomaster can be landed there. At both Moosonee and Churchill then, airport facilities will be satisfactory in the near future.

Churchill is the terminal of a Canadian National Railway line from Le Pas, with a direct connection to Winnipeg and Regina. Moosonee is the terminal of the Ontario Northland Railroad from Cochrane that connects directly to Toronto. Since most technical equipment is likely to come from the industrial Centre of the Eastern Provinces, Moosonee, which is 186 miles north of Cochrane and 668 miles north of Toronto, has the advantage of being some 2000 railroad miles nearer



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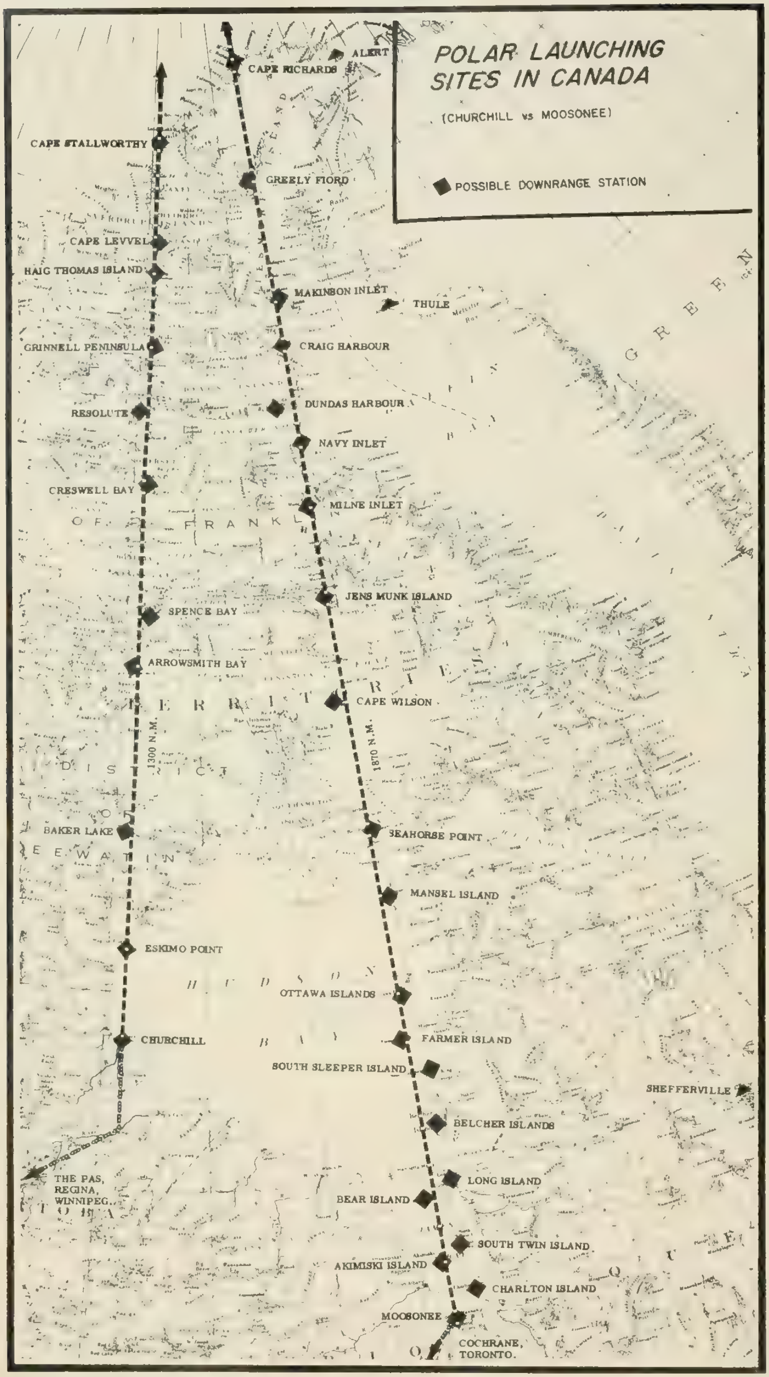
rangehead would mean flight of 1870 n.m. over Canada . . .



VAST DISTANCES offered by both suggested Canadian launching sites are indicated on this map showing possible downrange stations. The Moosonee rangehead would provide 1870 nautical miles over Canadian sovereign territory; a Churchill rangehead would mean 1300 miles across Canada.

to the sources of supply.

• **Starting from scratch**—Contrary to popular belief, the existing rocket launching pad support at Churchill is of no value in the construction of launching facilities for long-range rockets. A major facility would be altogether different.

It would be necessary therefore to construct such a facility at either of these two places essentially from scratch.

During the construction, as in subsequent operation, climate plays an important part. Climatic observations show that Moosonee is, on the average 15°F, warmer than Churchill throughout the year. On the average Moosonee also experiences above-freezing weather for seven months of the year, in comparison to four months for Churchill. Moreover, the extreme January frost conditions common to Churchill are rare at Moosonee. There is adequate housing both at Churchill and Moosonee to accommodate construction crews during the early phases of the development.

In summary, supply costs for Moosonee should be smaller than those for Churchill, although the actual difference is unlikely to be great. Construction costs are likely to be significantly less for Moosonee because of the higher temperatures and the lack of permafrost.

• **Looking down range**—The second factor is the construction of downrange facilities. The small islands in Hudson Bay and the larger islands of the Canadian Archipelago farther north make ideal locations for radio control, monitoring and interrogative stations for a Moosonee range. Churchill is also well provided in this sense, except for an important length, starting some 125 nautical miles downrange and extending 525 nautical miles, from Eskimo Point to Arrowsmith Bay. This length represents the main burning part of prospective rocket launchings, but still, it could be monitored easily from the end points and perhaps from Baker Lake. Other monitoring stations would introduce the difficulty and expense of inland siting. The position of Eskimo Point, Baker Lake and Resolute downrange from Churchill is a mixed blessing as they are relatively populous.

• **Range over Canada**—A third factor of importance in site comparison is the length or range within Canadian sovereign territory. The Moosonee rangehead is about 1870 nautical miles from Cape Richards on Ellesmere Island along the same Meridian, or geographical north-south line. The Churchill rangehead is 1300 nautical miles from Cape Stallworthy on Heiberg Island.

Under typical conditions final

rocket burnout may be expected to occur some 600 to 1500 nautical miles downrange, depending on the length of coasting before the final stage is fired. If an earth satellite vehicle were being launched, a further 1000 nautical miles of path length would be monitored, so that future behavior of the satellite could be adequately predicted.

For our purpose, a 1300-nautical-mile range is marginal, while an 1870 nautical-mile-range represents a considerable improvement. Of course, a 2500-n.m. range would be better if one were available, and we will indicate later how this might be obtained.

Consideration must also be given to the operation of the launching site once it has been constructed. In this connection, the majority of the work involved in launching rockets lies in transportation of the rockets between storage depots and the ramp, installation and checking. This is outdoor work and would be easier in temperate climate conditions. Building of permanent homes for the operating personnel is also less expensive under such conditions. It appears that Moosonee is preferable to Churchill, and in general, other potential locations across Canada.

• **Drawbacks elsewhere**—At the present time, the Western nations have available only one polar orbit launching site, located at Point Mugu in California. There is no sovereign monitoring for this site at all, all downrange activities being undertaken by picket ships in the open sea. Point Mugu also suffers the severe disadvantage that it launches rocket vehicles into the equatorial zone, where considerable dangerous radiation is trapped by the earth's magnetic field, as previously mentioned.

Examining site possibilities elsewhere in the world, it becomes evident that only Australia could provide an alternate range. An Australian polar range would have a sovereign path between 1000 and 1200 nautical miles in length, with the rangehead in the Northern Territory, near the coast. Launchings would be south over Antarctic regions, and downrange facilities could possibly be extended 1700 nautical miles out into the Pacific Ocean by means of picket ships. There is the disadvantage that supply to downrange stations, located in the central Australian desert, would involve considerable expense.

A range in South America would also be of interest to the United States, but the site would have to be carefully chosen to reduce hazards to the population, and it would probably be a major political undertaking. An African range does not seem possible at all due to the hazard to population. Any range of the length we have mentioned constructed in a north-south direction in Africa would inevitably pass over densely populated areas. Again there are political difficulties, because the range would not be confined within one country.

At Moosonee a rangehead could be constructed that would permit the use of a range extending over 1870 nautical miles over Hudson's Bay and the northern islands—and might conceivably be maintained for a further 500 to 1500 nautical miles from floating ice islands in the Arctic Ocean.

The area is suitable for construction. A few miles down the river from James Bay, the shoulders of land along the river rise above the muskeg and several square miles of drain land are available for launching facilities. The community itself, on the left bank of the Moose River, opposite Moose Factory, is 15 miles south of James Bay and would be south of the launching site, out of range of any potential danger, but immediately accessible.

• **Requirements and cost**—What about the magnitude of the facilities required for the rocket range and the cost of the project?

The basic requirements for launching facilities are as follows:

- At least two launching ramps, with a blockhouse protected against the lethal radius of rocket fuel explosion.
- Weather shelters for the readied rockets, which, with the maintenance and servicing platform, ride on rails so that everything can be rapidly withdrawn from the rocket before firing.
- Microwave and cable communications within the launching area. A storage depot, including an air conditioned room for maintenance of electronic equipment.
- A liquid oxygen generator and central fuel storage area.
- A power generator, probably diesel, of about 100 kilowatts capacity. A very high capacity digital computer for the setting of guidance systems, and general data handling.
- Two or three precision tracking radars on an accurate base line at the launching area.
- Adequate meteorological facilities for weather prediction.
- Housing for 150-200 men, the basic staff of the base. The approximate real estate would be about one square mile. We estimate the basic cost at about $30 million.

The requirement at each downrange station is roughly as follows:

- One precision tracking radar.
- One or two optical tracking instruments.
- One or two cine-theodolites, for tracing.
- One multi-channel telemetry receiver, microwave, telephone or ultra-high-frequency communication to the central launching area.
- Meteorological facilities.
- Housing for some 25 men.

The cost of each downrange station would be about $2 million. About 10 to 15 such stations will be required.

The total basic cost for the launching facilities and downrange monitoring stations comes to about $60 million. That is not a great deal of money in this day and age for what we would be buying—a unique rocket facility for the Western world, that could be emulated only, perhaps, in Australia. The rocket range would be a considerable contribution to the Northern development of Canada, as well as a major contribution to Western missile and rocket facilities.

EIA Gets 100 Millionth Packaged Circuit Unit

WASHINGTON—The 100 millionth "packaged electronic circuit" PEC was presented to the Electronic Industries Association here last week. The presentation, symbolizing 15 years progress in miniaturization, was made by W. S. Parsons, president of **Centralab,** to David R. Hull, president of EIA. Parsons predicted production of the next million units within 4½ years.

A PEC unit is a complete electronic sub-assembly made up of capacitors, resistors, inductors, and wiring printed and bonded to a ceramic base plate. The resulting sealed unit is extremely thin, with essentially only two dimensions. A four-stage amplifier so constructed has a density of over 500,000 components per cubic foot. The technique grew out of Centralab's World War II work on radio proximity fuzes.

Hull, in accepting the circuit—which will eventually be part of a Smithsonian electronic exhibit—said miniaturization can take much credit for the great progress of electronics. He said "the significance of this development to the Space Age is self-evident. Without packaged circuitry and other routes to miniaturization, the periphery of space would still lie beyond the reach of man. But for these developments, it is clear that the instruments upon which we today are totally dependent in space exploration still would be earth-bound, awaiting rocket engines far more powerful than any we have yet been able to produce."

It was pointed out that the vast amount of electronic equipment needed in the future would require more old-type soldered connections than could be produced by all the people in North America.

shifting emphasis . . .

How A Small Firm Meets Space Age

BALTIMORE—The sudden arrival of the Space Era, imposing demands for special skills in unexpected ways, has caused many small companies to undergo radical shifts in product emphasis.

A typical example is **Flight Refueling, Inc.** of Baltimore. Until two years ago, almost all of this company's sales were in the area of aerial refueling. Today, it is supplying such market as missile booster and disconnect valves, nuclear reactor valves and disconnects, flexible fittings for nuclear submarines, and special subcontract work on rocket bodies and electronic components.

The company is still in a transitional phase, however, and these new lines have not yet been built up to healthy proportions. Diversification now accounts for 30% of sales (compared with 10% in calendar 1958). The company says that it will in time account for a far greater proportion of business.

Much of the diversification is in the field of fluid flow. Understanding of how gasoline moves in an aerial refueling system has helped Flight Refueling's engineers solve flow problems encountered with liquid rocket fuels and reactor-generated steam.

• **Precision specialists** — A small company, Flight Refueling is not engineered or equipped for mass production of relatively rough tolerance pieces. Rather, the concern is making use of its machinists' skills and experience in precision work under government-certified quality control procedures.

Some typical jobs done recently in the missile field include: LOX and fuel servicing nozzles and adapters for the **Douglas** *Thor;* small stainless steel solid-fuel retro rocket cases used on several missiles; Dural booster disconnect valves for a classified missile program; consultation for **Martin, Denver**, on fluid flow problems in laying out *Titan* launching sites, and design study work on an entirely new system of missile handling.

Like many other small companies, Flight Refueling has contributed to some of the developments on its initial subcontracts, as well as initiating its own independent research and development programs in the new fields.

• **Picking a job**—In diversifying, executives must think long and hard about each bid opportunity lest they fritter away company resources. In aerial refueling, the market was fairly narrow and there was little question when and where to bid. This is not the case, however, with the new and diversified markets, many of which hold great promise for the company's technical team, but are somewhat of a mystery to the company's business and sales organization. The "digging out" of most promising prospects to determine those best adapted to the company's facilities, engineering talent and manufacturing skill is perhaps the most difficult problem which faces the management of the small company. Time, effort and money wasted on projects of limited future can, indeed, nullify much good effort toward diversification.

This situation is further complicated by the involved procurement requirements for defense products which often places the small engineering firm at a distinct disadvantage in competitive bidding.

"Perhaps the fairest method for the small company bidding on development projects," says William F. Whitesides, Flight Refueling's Engineering Manager, "is that used by a few of the larger companies. These companies request technical proposals without price on the first round of bidding. Then when the best technical solutions to the problem are determined by evaluation, they ask those two or three companies which have submitted the best technical proposals to submit priced bids for further competitive evaluation."

West Germans Uninterested in Moon Shots

by a M/R Correspondent

MUNICH—The recent agreement of the Council of the Western European Union to permit West Germany to manufacture certain antiaircraft missiles has not found enthusiastic approval among West German experts.

"We do not have any desire to help develop deadly weapons, even if we are permitted to do so! said a noted scientist who does not want his name revealed. "We have great plans—but only with small rockets and missiles and for pure scientific purposes. We do not even want to shoot for the moon!"

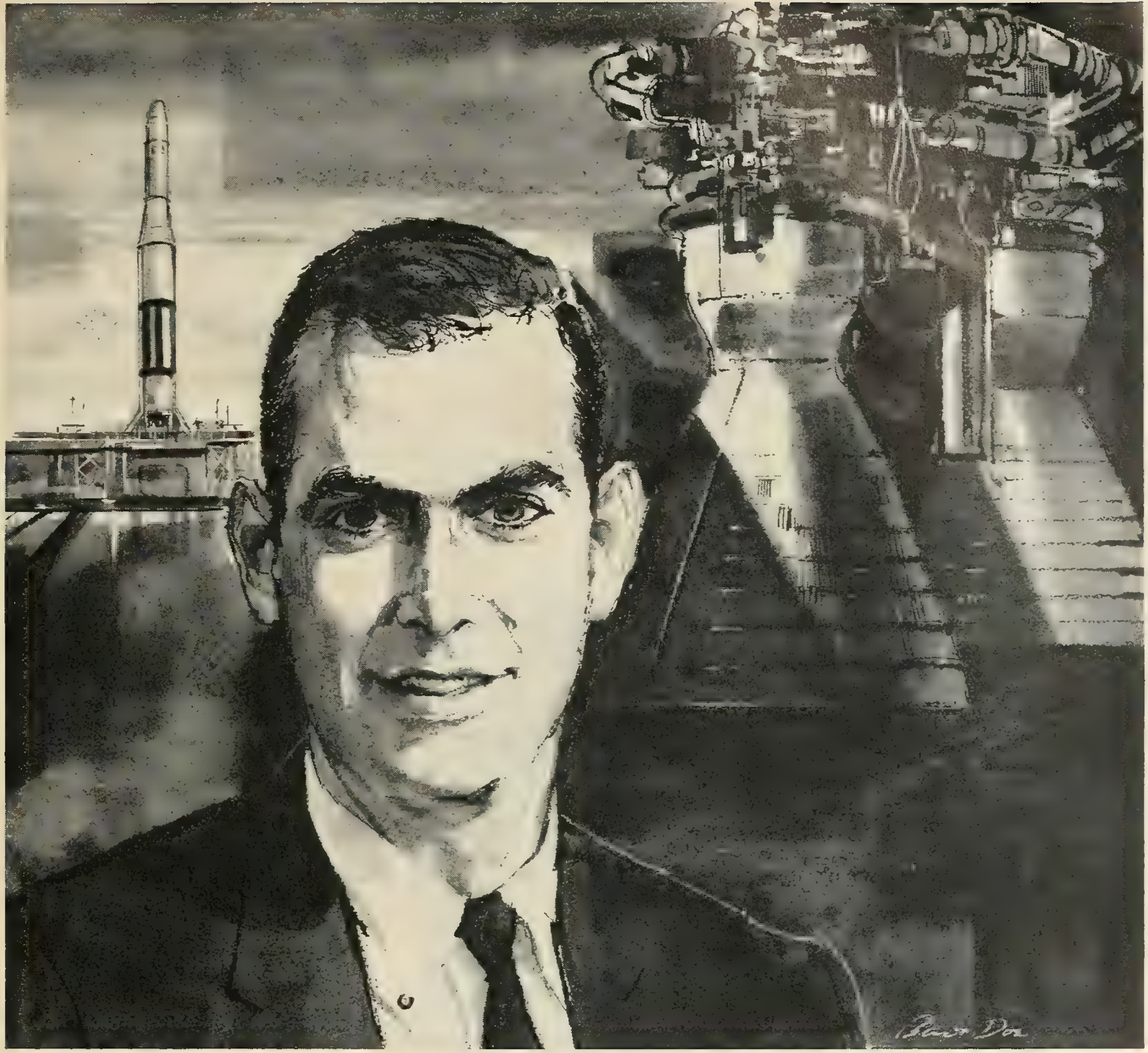
Among the scientists presently working in Germany are such well-known men as Professor Herman Oberth, the "Father of the Space Age." Last year he returned from the U.S., where he had been working with ABMA, to his home near Nuremberg.

The town of Stuttgart is the home of Professor Dr. Eugen Sanger and his physicist-wife, Dr. Irene Bredt. Sanger is the head of the "Research Institute for Jet-Propulsion" there. He is better known as the originator of the "Antipodal-Glide-Bomber" and the "Photon-Rocket." The latter theory, published in 1955, is believed to be the ultimate goal in space flight. Exhaust velocity of a photon-rocket would be equal to the velocity of light in a vacuum.

•**Substantial activity**—There are two astronautical organizations presently working very actively in West Germany. Both belong to the International Astronautical Federation whose new president is Russia's professor Sedov. The "German Society for Rocket-Technology and Spacetravel," headed by Prof. Sanger, and the "German Rocket-Society," under its president Dr. Ing. A. Staats.

The latter group puts main emphasis on experiments on a practical scale; the first group under Prof. Sanger is mainly engaged in theoretical research. Both groups have one common problem: a meager budget.

It has been possible, mostly through private contributions, to erect a new static test-stand near the town of Wildeshausen. First tests with rocket-motors developing a thrust up to 20,000 lbs. will start next spring.



A. L. Feldman

Al Feldman is thirty-one. A Cornell BSME, he joined Aerojet as a development engineer in 1954. His present job: Head, Propulsion Systems Department, Liquid Rocket Plant, Sacramento. The assignment: design and development of rocket engines for the TITAN missile.

His talent for careful analysis and willingness to meet the toughest problems have brought Al Feldman recognition and responsibility. But his progress at Aerojet is not unique. We'd welcome the chance to discuss similar opportunities with *you.* Send your resume to: Director of Scientific and Engineering Personnel, Box 296J—Azusa, California, or, Box 1947J—Sacramento, California.

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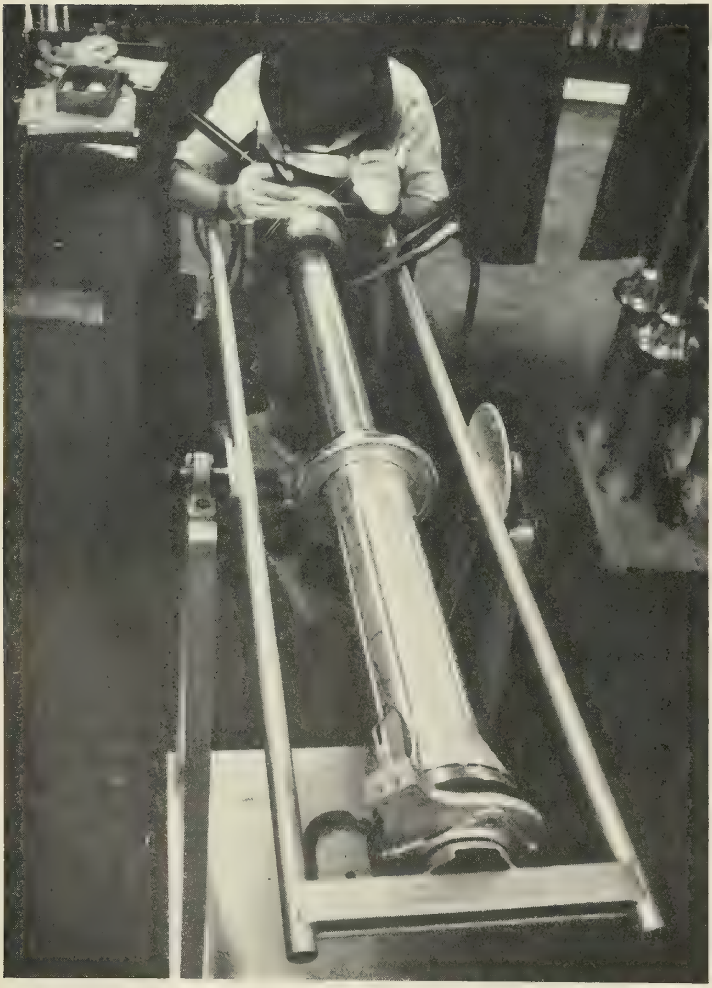
Will *Titan* Switch To Storable Fuels?

Prepackaged liquid systems concept profits from advances in storable fuels and oxidizers; encapsulation techniques may be applicable



FINAL SUBASSEMBLY welding operation of a stainless steel deflector for Thiokol Chemical Corporation's Guardian I packageable engine combustion chamber.

by John Judge

WASHINGTON—Storable liquid propellants have developed to the point where they are threatening areas now exclusively occupied by cryogenics and solids.

The technology is such that **Aerojet-General** is currently engaged in research and development involving the feasibility of converting the high-thrust *Titan* engines to storable fuels.

The advances in these power sources are directly proportional to the progress in prepackaged engines, since the "canned" engine is only as good as its propellant.

"Canned" units—in which the liquid propellant, oxidizer and pressurizing medium are sealed into a tankage shell which in turn, is integral with the rocket thrust chamber—are rapidly approaching maturity.

In essence, the high performance characteristics of liquids and the reliability, storability and handling ease of solids are combined in the prepackaged engines.

• **An old idea**—The concept of canned units is not new. German engineers were entertaining the idea at the end of the Second World War. But the early interest was somewhat discouraged by the comparatively low levels of energy available in storable liquids. Today, however, with all the advances in the chemistry of various compounds, the activity has increased tremendously.

Basically, a prepackaged engine consists of two propellant tanks, a pressurizing medium and a thrust chamber. Many variations of this configuration are possible. For instance, an experimental engine developed by the Naval Ordnance Test Station at China Lake, employs a burst diaphragm method to mix the propellants in the chamber. The trend is toward simplicity, both in design and operation.

The propellant combinations are forced under pressure into the reaction chamber where they ignite on contact if hypergolic, or some small initiator is used if they are not. The pressure medium can be stored gas, a small simple solid-propellant gas generator or a liquid chemical type. The pressure medium must be small, self-starting and provide constant or controllable generation throughout its operation.

The components must be able to withstand all storage, handling and environmental requirements.

• **Basic advantages**—The advanages in the prepacked concept evolve from the system's ability to combine the best features of both the liquid and solid engines in one simple device.

Such propulsion units are instantly ready for firing and capable of long-term storage without ill effect; they reduce support equipment to a minimum, and because of the simplicity of the device, its reliability factor is excellent.

In addition, canned units may be factory-adjusted for different missions. Blending of various fuels and oxidizers provides the optimum combination for any given job. This also holds true for environmental requirements imposed by the climatic conditions at any given launch site.

Many propellant combinations are hypergolic, thus simplifying the starting and restart problems. The entire powerplant when ready for firing is completely safe, since the propellants are inert until mixed for reaction.

Finally, the entire engine lends itself to comparatively easy scaling operations. The size range is almost unlimited.

• **Future expansion**—Aerojet confidently predicts that by 1961, it will have storable systems which will exceed the I_{sp} of most of the present day cryogenics with the exception of the hydrogen-fluorine system. The theoretical I_{sp} of the current storables is in the 275 to 290 second range (1000 psi at sea level) and Aerojet expects to increase the vacuum I_{sp} from the present 315 seconds to 360 seconds.

Thiokol is also on record as a cryogenic competitor. Its packaged Guardian units already power the Navy's *Sparrow III* and *Bullpup* missiles. **Reaction Motors'** Guardian series have been scaled up experimentally to deliver 50,000 lbs. thrust. Company spokesmen point out that none of the inherent advantages of the smaller units were lost in the scaling operation.

Both of these companies have been working with the prepackaged concept for a long time.

There is evidence that **Rocketdyne's** activity in this area is considerable. Research is underway toward tailored mixtures for specific applications and new metallic and non-metallic materials are being developed for use with corrosive liquids.

Much of the effort in packaged systems is classified, since the basic concept particularly appeals to the military. Aerojet is devoting considerable time to design considerations, in thrust chambers, nozzle configurations, injector design and materials of construction. Thiokol is also involved in enlarging the Guardian family; it can be assumed that others are pursuing such avenues.

• **Encapsulation proposed**—A serious problem in prepackaged engine development is that the tank materials must be compatible with the propellant combinations. Many compounds that could be used as oxidizers are extremely reactive and unstable. A suggested means of incorporating these substances into fuel systems is to encapsulate them in small pellets instead of containing them in large tanks. The possible uses of capsules in rocket propulsion are obvious: they could contain oxidizers, dampers or exotic additives, remaining inactive and protected until the instant of use.

Scientists at the **Southwest Research Institute** point out that another concept in prepackaged engines could be based on encapsulation. Such an engine would change from a liquid to a free-flowing solid system, the liquids being encased in thin, uniform, continuous films.

Recently, the Institute's Department of Chemistry successfully metal-coated a liquid-containing capsule. The laboratory method involved freezing the capsule and dipping it in a bath of a low-melting metal. Although the technique was proven feasible, a great deal of research is necessary before such capsules could be manufactured in quantity.

• **Propellant Combinations**—The heart of the prepackaged engine is the storable propellant. With the exception of ammonia and hydrogen, the known energetically-useful liquid fuels are generally stable under ambient conditions. The oxidizer is the problem child. Elemental fluorine and oxygen are definitely the highest performing oxidizers known to man. All of the other oxidizers, solid or liquid are inherently inferior because of the available energy loss involved in combining these oxidizing elements into a molecular structure containing elements of lower oxidizing potential. But, obviously, cryogenics are not easily stored.

Apparently no single oxidizer or fuel exists which can be designated as the best propellant. No single propellant system can satisfy all of the requirements for all conceivable missions. Therefore while the prepackage concept is adaptable to 99% of present and anticipated propulsion needs, the fuel and oxidizer combinations may very well differ from unit to unit.

Considerable improvements have been made in storable oxidizers. The most familiar compounds are the modified nitric acids. And of these, the standard is inhibited red fuming nitric acid. A propellant consisting of unsymmetrical dimethylhydrazine and IRFNA has been stored for as long as three years at a temperature of 165°F. Nitrogen dioxide provides a higher performance level. Others in use include nitrogen tetroxide and hydrogen peroxide.

Chlorine trifluoride seems to be up for future investigation, primarily because it is about 30% denser than the conventional oxidizers. In terms of performance, density, hyperglocity and low freezing point, the trifluoride is an excellent oxidizer when used with amine or hydrazine base fuels.

Propellant combinations of possible future interest for canned systems are under development. I_{sp} of 290 to 300 is thought to be possible with a nitrogen tetroxide-lithium borohydride system, although the borohydride would have to be liquefied somehow. High density combinations such as aluminum borohydride-bromine pentafluoride yield a calculated density specific impulse of 450 seconds.

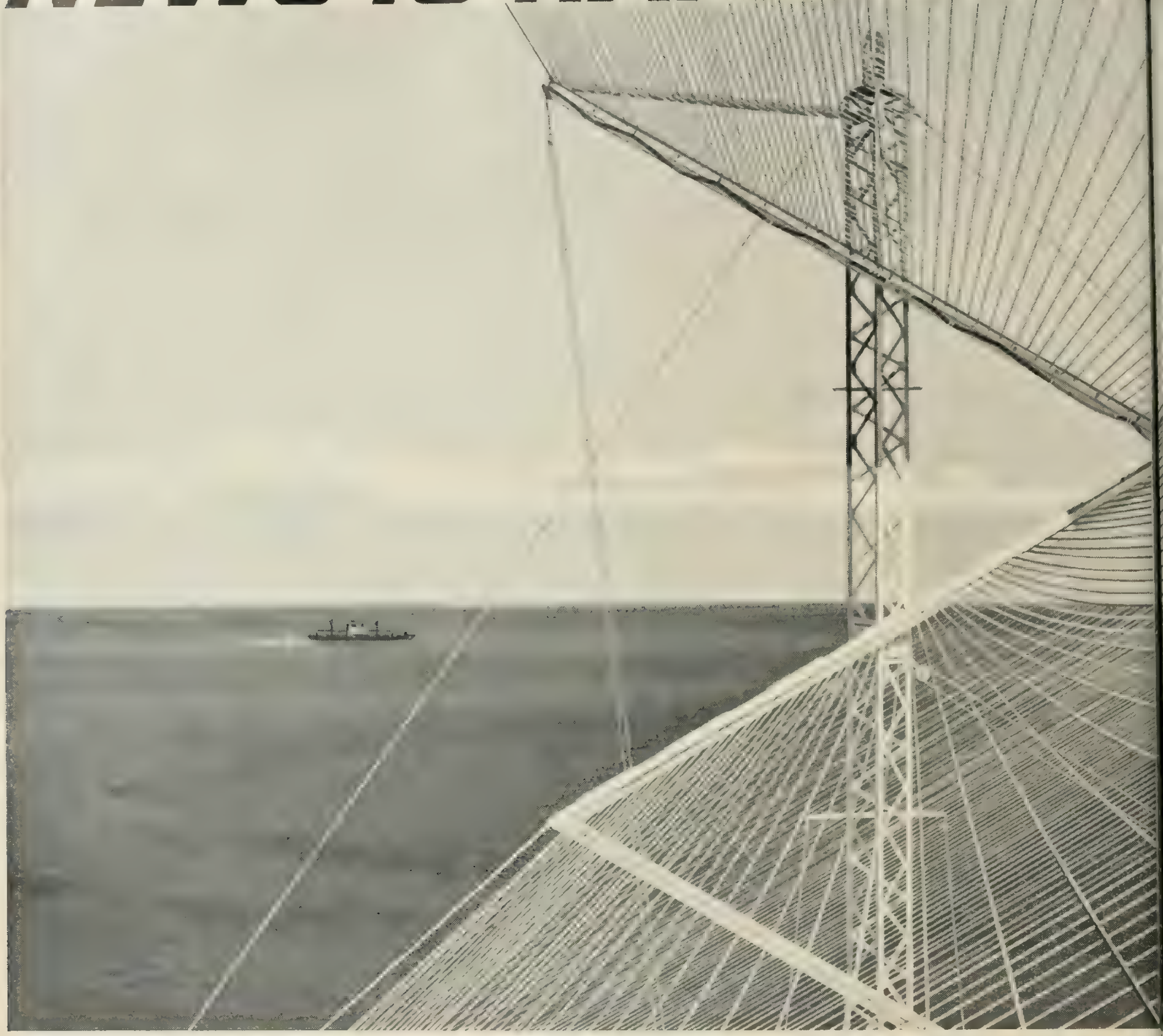
The application of the canned engine concept to ICBM and IRBM systems is an ideal one because of the instant readiness and high performance characteristics. Further, upper stages might effectively utilize a small packaged unit as a precise means of thrust vectoring. Since the engines could be easily shut off and restarted, the exact orbit might be plotted on the ground and the unit them turned on to achieve the mission.

Some space probe missions can be handled efficiently with the packaged engine, but the more difficult aspects such as soft lunar landings and deep space probes will still depend on the cryogenic systems.

Another interesting thought is the possibility of placing canned units in precise orbits. Then a system resembling the pony express concept—periodically replacing tired horses with fresh ones—could be utilized for the completion of advanced space missions.

The feeling is that the packaged engine may well be America's first all-around, off-the-shelf, high-performance thrust system within the very near future.

NEWS IS HAPPENIN



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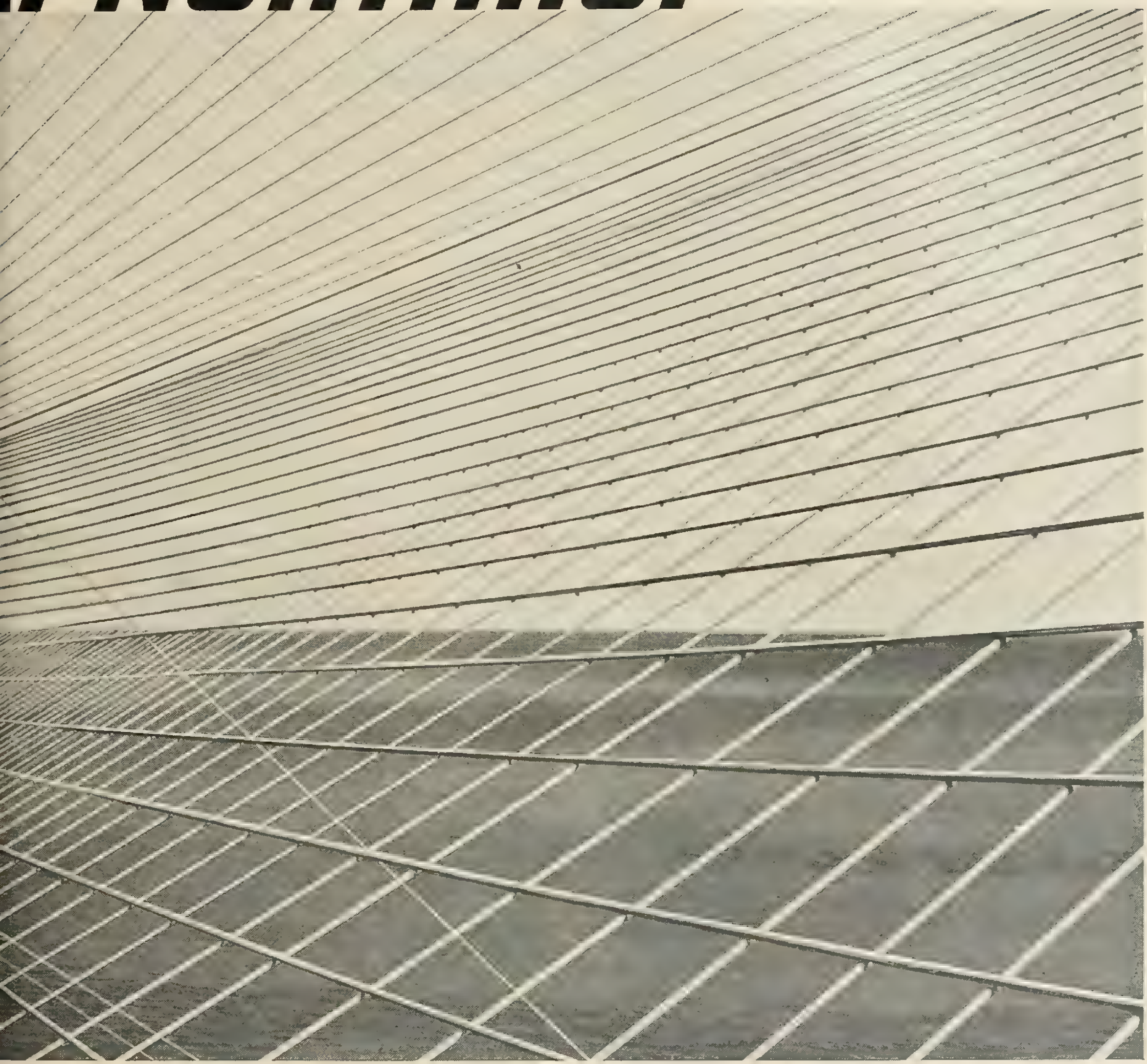

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Transporting Big Boosters by Water

Plant-to-launch pad logistics is essential preliminary design consideration for multi-meg rockets; land, air travel is limited

DOWNEY, CALIF.—Designers of big rocket boosters for space vehicles have a problem as prosaic as the do-it-yourselfer building a 40-foot yacht in the cellar. How do you get it to the launch pad without taking the house apart?

This is a question which must be resolved before construction starts—very definite limitations exist in the various types of air and land transportation.

Only ships and barges offer no restrictions as carriers of oversize space vehicles. But, because there is a considerable problem in metropolitan areas in moving a 22-foot diameter booster even a short distance overland, suggestions are being advanced to locate the manufacturing plant near navigable waters.

This preliminary design consideration must be taken into account for the Nation's two big boosters—ABMA's *Saturn* cluster of eight **Rocketdyne** H-1 liquid engines and NASA's F-1 (formerly called *Nova*) also being developed by Rocketdyne–now in the program stage. Both these boosters will have about 1.5 million pounds thrust. *Saturn* will have an overall diameter of more than 20 feet and the exit nozzle of the F-1 alone will be larger than 12 feet in diameter. The booster propellant tanks for the F-1 are expected to create a number of logistic problems. And if liquid hydrogen is used, the tanks will be even bigger.

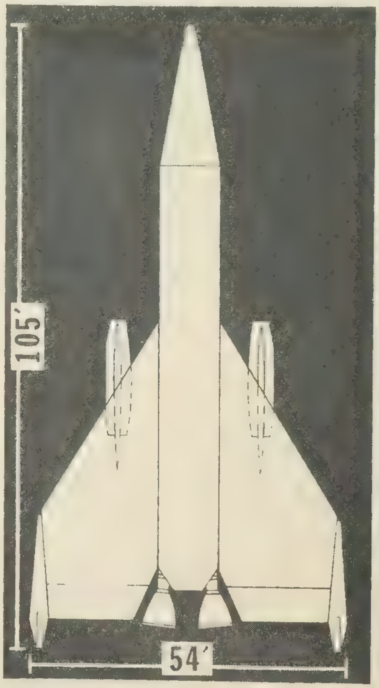
There are several other concepts being advanced for multi-meg-thrust boosters, including ones by **Aerojet-General** and **Thiokol,** which also must take into account the plant-to-launch transport problem.

A definitive study of the availability of transport has been made by Louis J. Walkover and H. L. Woodlief, Jr., both of **North American Aviation's** Missile Division. Their report, available to industry and government, is a compilation of all the standard means of transport via land, sea and air, and delineates their various physical and legal limits.

• **Flyable manned boosters?**—Ideally, the transport problem could be met with the least difficulty if the oversize booster could be flown to its destination by a pilot—the same as giant SAC bombers. Or if the booster is assembled at the launch site.

In the case of *Saturn,* which is being assembled and tested at Huntsville, Ala., it is proposed to put the big booster aboard a barge and tow it via river and the ocean to Cape Canaveral for launching. It has also been proposed to airlift the booster with a dirigible or blimp.

Walkover and Woodlief point out, however, that a lighter-than-air blimp large enough to carry a big booster would have to be developed first. And the science of dirigible building is 20 years out-of-date. They also point out that the development problem would apply to a helicopter. One that has been proposed to lift an 80,000-pound payload would have a range of only 100 to 150 miles without refueling.



HUGE MANNED recoverable booster would be moved by water or possibly flown from plant to launching site.

There are other forms of aircraft which might be useful, but they also would require development first. One type would be a conventional fixed-wing aircraft without a fuselage, in the true sense, which would carry the cargo in a pod suspended from the wing. Another approach would be to enlarge a conventional air cargo plane to handle big objects.

The largest available cargo plane today—the **Douglas** C-133A— can just accommodate the 10-foot diameter *Atlas* ICBM. So any booster of larger dimension must be transported by another means.

• **High transport costs**—Highway and rail transport are almost as restrictive as air transport. The study found that right-of-way railroad and highway clearances—even in cases where special routes and special permission was obtained—are limited to loads of a maximum 13 feet in diameter. Normal maximum diameter for highways is 8 feet, for railways 10 feet.

No matter how the transport problem is tackled, the report finds that it invariably will be expensive for boosters of 20-foot diameter or more because of the special handling involved.

Along the highways, special trailers would be required to carry the vehicle. And, aside from multifarious state highway laws (one state permits *Atlas* on its highways only from 10 a.m. to 4 p.m. weekdays and not at all on weekends) which complicate movement, there would be added expense in relocating power and telephone lines along the route, as well as traffic signs, signal lights and trolley cables.

While truck transport in the West often appears feasible for oversize loads, it gets less attractive in the Eastern part of the country because of older highways, underpasses, towns and more numerous rivers to be crossed.

• **Ocean carriers**—Large ocean ships are satisfactory for shipping oversize airframes from one coastline to another or to the Great Lakes. Ocean-going commercial ships can carry large bodies as deck cargo lashed to the upper deck or as hold cargo stowed vertically down the cargo hatches. Special-purpose Navy ships such as LST's and LSD's can also carry large airframe bodies. Ships that could be used to transport oversize airframe bodies also include C-series cargo ships, Mariner cargo ships, T2-SE tankers, and Navy aircraft carriers and seaplane tenders.

Sea barges can carry large bodies and could possibly be towed directly into the inland waterway system without a transfer.

Some of the problems in ocean shipping are a little different from those in other means of transport. The cargo must be well protected from the sea if it is carried on deck. And the loading of the cargo on and off the ship requires overhead cranes and accurate positioning within confined spaces that could do additional damage en route.

Shipment of cargo by water carrier may be handled in several ways. The first way could be the use of commercial marine carriers that operate between specified ports or stations in the same way as a railroad. The disadvantage of using a common carrier is that they seldom go to the exact place desired.

An example of this can be found in water delivery of an oversize body to AFMTC, Florida. None of the commercial carriers makes scheduled stops at Port Canaveral. The closest regular stop is Charleston, S.C., at normal intervals of 1 to 4 weeks. A few lines will stop at Jacksonville, Fla., if given advance notice and special inducement pay.

In any case of this type, the cargo would have to be transferred to a barge and towed to Port Canaveral. There is the possibility that a carrier can be prevailed upon to stop and unload at Port Canaveral at the expense of an inducement fee.

The second means of ocean-going transport is via one of the ships of MSTS (Military Sea Transport Service). This service was established in 1949 for the control, operation, and administration of ocean transport of cargo, and personnel for the Department of Defense.

The operations involve the movement by sea of, and logistic support for, the Army, Navy, and Air Force outside the United States. DOD will authorize MSTS to support other agencies of the Government and to plan and negotiate for use of commercial shipping when necessary. Without the help of the commercial shipping industry, MSTS could not meet its commitments. Privately owned ships of the U.S. Merchant Marine carry over 70% of the military cargo. The MSTS fleet is made up of transports, cargo vessels, aircraft carriers, tankers, LST's, and various types of specialized ships. There are no LSD's in this fleet at the present time.

The MSTS is operated along the lines of a commercial business and its operating cost per ship is considerably below that for a similar ship manned by Navy personnel in fleet service. One of the reasons for the higher cost of a Navy ship is that the number of Navy personnel required aboard a typical VC-2 type (Victory) ship is about 250 as compared to approximately 50 men when the ship is in service with MSTS. Following are approximate operating costs for a complete ship in MSTS service, but do not include any loading or unloading costs.

Cost Per Day

LST	$2250 per day
LSM	$1025 per day
AKL	$1500 per day
APZ	$2700 per day
C4	$3500 per day

The crews of the MSTS ships are civil service employees and not subject to a strike as are those crews aboard commercial ships. This fact could be important when the shipping time of a cargo is critical. There is an MSTS office in San Pedro, Calif., where additional information may be obtained concerning this transport service.

It was the consensus of persons contacted on the subject, that obtaining a regular Navy ship and its crew would be very difficult and undesirable for the transport of special cargo of the type considered in the report.

• **Cheaper by water**—In practically all cases, ships are loaded in this country by self-contained booms and hoisting equipment. In most foreign ports dockside cranes and overhead hoists are used for loading and unloading. Oversize loads would have to be hoisted on and off a conventional type ship.

Because of size and/or weight of cargo, it might be necessary to employ a dockside crane or possibly a floating crane along-side the ship to load and unload. Cargo does not have to be transported directly to a dock alongside the ship for loading—although this is most desirable—but instead may be loaded into a barge or lighter at one dock and moved across a harbor to the ship at its berth where it is hoisted aboard over the farside.

Transport Logistics

AIR TRANSPORT	SURFACE TRANSPORT	WATER TRANSPORT
INTERNAL CARRY	8 FEET DIAMETER	ONLY SIZE LIMITATIONS FOR WATER TRANSPORT ARE REQUIREMENTS FOR LOCAL ROAD TRANSFER FROM FACTORY TO PORT AND FROM PORT OF DEBARKATION TO LAUNCH SITE
C-133 AIRCRAFT	NORMAL RAIL AND MAX. ROAD TRANSPORT MODES	
10 FT. MAXIMUM TANK DIAMETER ON SPECIAL LOW BED TRAILER	10 FEET DIAMETER	
	MAXIMUM RAIL TRANSPORT MODE	SHIPS CAN CARRY 22 FT. AND LARGER DIAMETER TANKS
EXTERNAL CARRY	ROAD TRANSPORT REQUIRES SPECIAL PERMIT (WIDTH DEVIATION) AND SPECIAL LOW BED TRAILER	HARBOR AREA TRANSPORT
POD MOUNTING		17 FEET DIAMETER
HELICOPTER	13 FEET DIAMETER	RAISING OF MINIMUM NUMBER OF OVERHEAD WIRES
LIGHTER THAN AIR	ROAD TRANSPORT WITH PERMIT (HEIGHT AND WIDTH DEVIATION) SPECIAL LOW BED TRAILER AND SELECTED ROUTING	22 FEET DIAMETER
	RAIL TRANSPORT WITH SELECTED ROUTING	RELOCATING OF ALL OVERHEAD WIRES

Oversize cargoes and heavy lifts have a higher tariff rate and require more insurance, boosting shipping costs. Even so, a large airframe body can be shipped much cheaper by water than any other means. Shipping costs may be obtained directly from the carriers involved in some cases. In other instances, estimates may be made by consulting the Freight Tariff Manuals published by Harry S. Brown, Agent, New York City.

Information on dimensions and crew complement for any Navy vessel can be obtained from the "Booklet for General Plans" for that particular ship and is available from any Naval Shipyard through the Navy Plant Representative at North American Aviation. Commercial-type ship information can be obtained from the Federal Maritime Administration, Washington 25, D.C. and from commercial carriers who have the various types of ships in service.

Analogue, Digital Computers Wedded

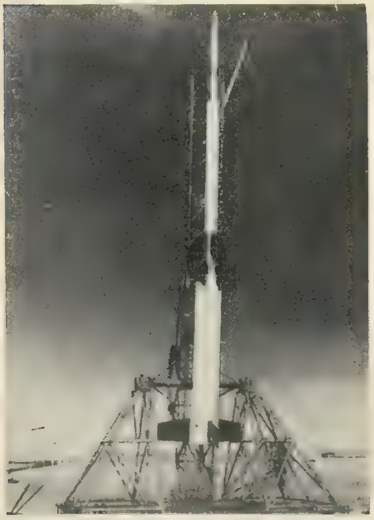
by G. V. E. Thompson

LONDON—A hybrid system combining the high-speed and flexible programming of the analogue computer with the accuracy and speed of data-processing of the digital computer has been developed for missile homing investigations.

This automatic computer was described by J. G. Thomason of **Imperial Chemical Industries'** Central Instrument Laboratory, Reading, in a paper given recently to the Society of Instrument Technology.

This development arose out of an analogue computer investigation into guided missile system performance, made at the Royal Radar Establishment. During the investigation it was noticed that operation of the computer and subsequent reduction of the data were making excessive demands on labour which might have been employed on more creative tasks, particularly when effects of noise in a missile system were being studied. This involved making many repeated runs on the computer to obtain statistical results.

To overcome this, a project to fit an "automatic operator" and "automatic clerk" to the analogue computer was undertaken. In the system finally achieved, the analogue computer runs and resets its parameters in response to an input program punched on conventional 5-hole paper tape. Results are encoded and punched on an output tape, which is fed to the digital computer. This reads the tape and prints out tabulated reduced data. It can also operate a graph plotter if necessary.



AUSTRALIAN-built *Long Tom* rocket on launcher at Woomera. It is 27 feet long and weighs nearly one ton.

Instructions for the analogue computer are read on a Creed tape reader converted for parallel operation and feeding the usual relay tree producing a 24V pulse on one of 32 terminals. These are conveniently named as in teleprinter practice, so that programming is reduced to punching letters.

The computer, developed in Thomason's laboratory, does not use standard commercial units. The operational amplifier in the analogue configuration is a non-drift-corrected 4-valve DC amplifier with a gain of about 12,000. Drift is cancelled by a separate zeroing unit using a motor-driven potentiometer to set the bias between runs. The divider circuit incorporates a cam-corrected potentiometer for each plane. The delay is continuously variable from 100 microsec. to 1 sec. in four switched decade ranges.

Summation, integration and limiting are conventional. A feedback method of obtaining quadratic-lag transfer functions is used in preference to complex single-amplifier configurations in order to achieve independence of control of frequency and damping.

The analogue-to-digital converter is of the conventional stepping-switch type working in binary code. Provision is made for accepting two analogue inputs and converting these in sequence.

The space and three of the four format instructions provided for teleprinter purposes are used to program the computer operations. One character is used to make the computer repeat the run the number of times that has been set on the run counter dial, to obtain statistical results. No more tape is read until this number of runs has been made. From 10 to 110 runs, in steps of 10, may be made. Indicators are provided for showing the number of runs already performed in a 'count' sequence, and the total number of runs.

Another character facilitates unattended running. When placed at the end of the program tape it cuts off the main supply to the whole computer. A time switch is also incorporated so that the machine warms itself up for an hour in the morning before it is needed.

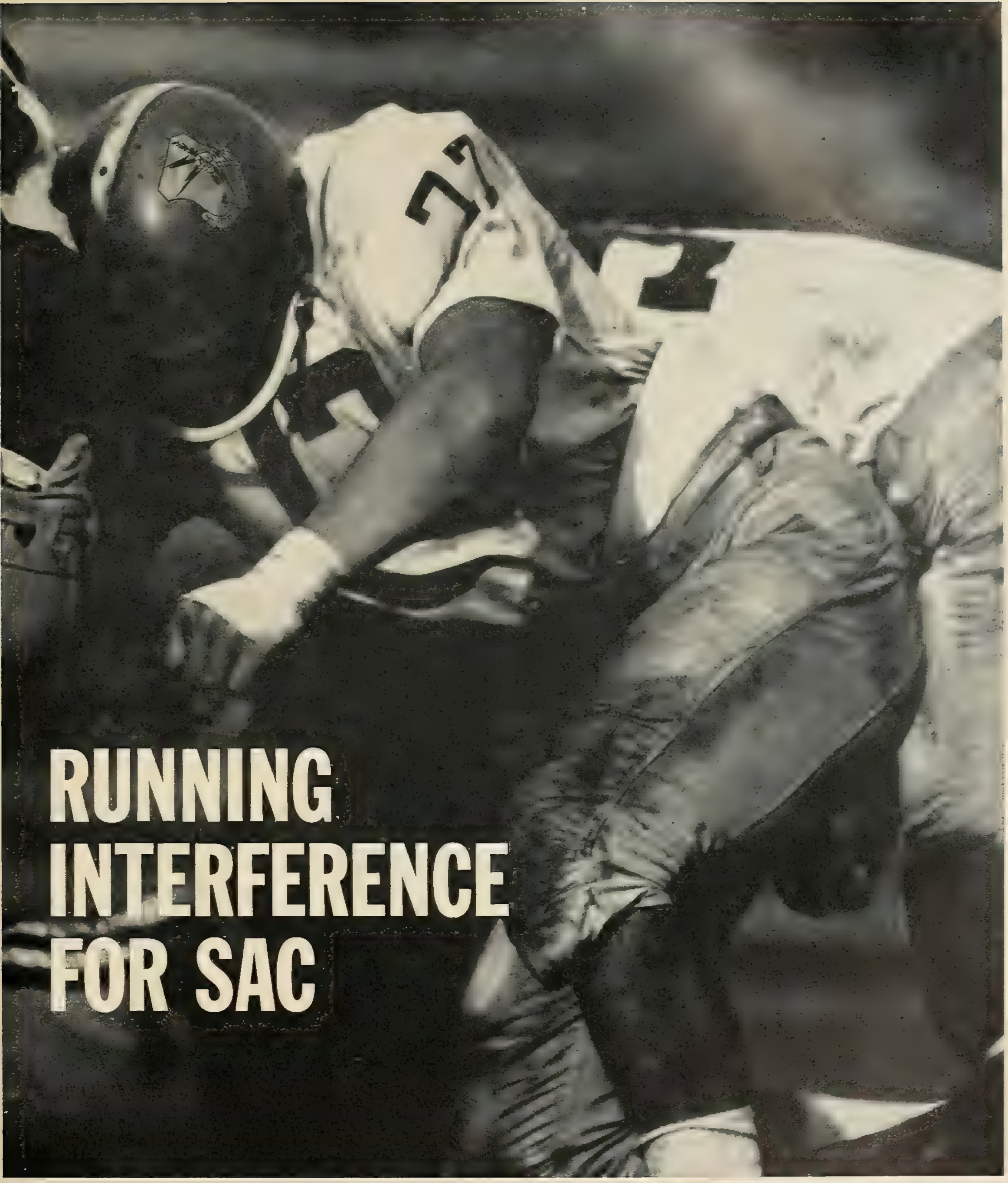
A special lightweight, high-performance, stabilized power unit has been designed. Its output is +300V 0-100mA; –300V 10-100mA; and –960V 1mA (not stabilized).

All timing is referred to the divider potentiometer. The timing potentiometer has a large angle of operation to overlap the divider potentiometer, and there are six comparators, one spare and five giving the timing for pre-beginning (release clamp circuits), missile stimulus in (preset), target stimulus in (preset), end of run (measure miss-distance), and post-end of run (operate clamp circuits).

Miss distance is given by the voltage representing displacement error at the instant engagement ends. The charge is stored on a distrene-film capacitor with voltage indicated by a low grid current precision cathode follower driving a centre-zero milliameter.

The noise generator takes non-white noise from a thyraton and uses a mechanical relay modulator to select part of the noise spectrum which is fairly level.

ANOTHER two-stager, also Australian-built and used at Woomera, is the 21-ft.-long *Aeolus,* weighing a half-ton.



RUNNING INTERFERENCE FOR SAC

Now SAC's B-52G has a pair of hard-running teammates ... the GAM-77 Hound Dog air-to-surface missiles. They can lunge into action at supersonic speeds to clear a path for the bomber by knocking out ground-defense centers hundreds of miles away. A pair of Hound Dogs carried under the wings of the Boeing B-52 increases the bomber's striking power ... gives it a triple-punch capability. Successful test launches of the jet-powered missiles are being made on schedule over the Atlantic missile range. The system will be deployed by 1960 under the present accelerated development program.

The Missile Division of North American Aviation is weapon system contractor for the GAM-77.

MISSILE DIVISION

NORTH AMERICAN AVIATION, INC., DOWNEY, CALIFORNIA

'Lunar Suit' Proposed for Astronauts

Martin Co. design provides environmental controls, communications capability and sensing equipment for emergencies expected on moon

BALTIMORE—Electronics will play a major part in the uniform of a well-dressed lunar explorer. His protective suit will contain at least three complete electronic subsystems—for environmental control, communications, and emergency sensing. Essentially, the suit must provide the wearer with the same environment he now enjoys on earth.

Such a proposed "lunar suit" was described here during the recent IRE Aeronautical and Navigational Electronics Conference by three **Martin-Baltimore** engineers: F. J. Conley, R. K. Cassatt, and M. A. Grodsky. They pointed out that in order to survive on the moon, man must be protected from the hostile environment and yet be able to communicate and move about.

That the moon's environment is hostile is not questioned; but the extent and exact nature of these dangers are not known. Equipment design today must be predicated on existing knowledge and intelligent estimates. According to the Martin scientists, many of the hazards to man's ability to live and operate on the moon can be reasonably assumed. Among them are:

- **Cosmic radiation**—Although little information is available on this subject, it is known that primary cosmic rays are very energetic and dangerous secondary radiations can also be present. Such radiations undoubtedly are present on the atmosphereless moon.
- **Van Allen radiation**—Preliminary satellite test results indicate the possibility of high-intensity radiation in the area of the moon. Levels can only be guessed at, but the intensities may be dangerous.
- **Meteorites**—Damage may be inflicted on a man and equipment by meteorites or dust particles. Large particles may penetrate the protective covering of a space suit and equipment packages; small particles could produce erosive action on optical and solar battery surfaces.

PILOT'S HELMET equipped with a miniaturized radio transmitter is shown by Martin Co. engineer Francis J. Conley.

In spite of the theory that meteorite impacts on the moon may range up to about 160 per hour per square meter, however, it is not certain that they will cause serious problems. *Vanguard I* has been in orbit for over one and one-half years and has suffered no detectable damage. Other satellite evidence indicates relatively small damage by meteorites.

- **Temperature**—Surface temperatures of the moon may range from +215°F during the lunar day to −243°F during the night.
- **Atmospheric pressure**—Based on radio telescopic observation, atmospheric density of the moon is in the order of 2-6 x 10^{-13} earth atmospheres. The upper limit is usually considered to be about 10^{-7} atmospheres.
- **Solar radiation**—The solar radiation level on the moon's surface has been estimated to be well within man's tolerable limits.
- **Magnetic field**—The magnetic field surrounding the moon is in the order of 0.14 x 10^{-5} gauss. Based on these expected environmental conditions, protective and operational measures would depend to a large extent on reliable miniaturized electronic equipment.
- **Space environmental control**—The space explorer must be maintained in an environment very near that of earth. This can be done with electronic control and sensing devices not too different from those presently used in high-speed jet aircraft and high-altitude balloons.

Temperature can be held within tolerable limits with an electrically heated suit. Thermistors could be used as temperature-sensors. Individual circuits for each portion of the body would compensate for the wide temperature variance between the man's head and feet during the lunar day.

The pressure within the suit must also remain constant. A suit pressure of 5 psi would give a satisfactory equivalent earth altitude of 27,000 feet.

Electronic sampling and sensing devices would monitor carbon-dioxide, oxygen content, and other trace gases to ensure that the chemical recycling filters operated properly.

Under certain conditions, current operational pressure suits allow the wearer's breath to condense on the inside of the face plate. Electrically heated double-walled facepieces would be necessary to prevent fogging and frosting.

Estimates indicate that there is 30% more light on the moon than on earth. In addition, since there is no diffusing atmosphere, transitions from high to low light levels would be severe. A device to limit the intensity of light entering the face place would be needed to prevent retinal burning. It would have to be operated by the light source itself; as intensity increased, a sensing unit would actuate a protective shield of shutters or polaroid lenses.

- **Communication equipment**—Exploration parties on the moon will require radio for communication between individuals and their vehicle or home base. A UHF line-of-sight link will be used for its noise-free characteristics, proven reliability, and small antenna sizes.

For more efficient communication, the system should emulate, as far as possible, human voice characteristics. Signal strength should be proportional to oral volume, with range limited to points normally reached on earth by a shout. Antenna radiation patterns would resemble normal voice propagation (forward and directional). A switching arrangement would permit omnidirectional full-power transmission during an emergency. Radio equipment must be miniaturized, efficient, and reliable, with power outputs in the order of 600 mw.

- **Emergency sensing equipment**—Since the slightest malfunction could cause serious injury or death, all environmental and communication subsystems must be adequately monitored. As an example, in the case of oxygen failure, a man's system undergoes certain characteristic changes which can be electronically sensed and a warning activated. Repairs or adjustments can be made before serious injury occurs.

All the system indicators, functional switches, and controls must be within easy reach, with a miniaturized control panel mounted on the forearm or top thigh of the suit. The electrical wiring bundle could be molded into the suit's fabric outer layer to prevent damage, and terminate in a quick-disconnect which would plug into the back support-pack.

There is a possibility of exposure to a meteor shower that could puncture the space suit or damage the equipment. Consequently, a device mounted on the suit or helmet to record the impact of particles would be necessary. The frequency of hits would warn of an oncoming meteorite shower and allow the man to return to base or seek natural shelter.

These and other considerations presented in the paper, although speculative to a degree, pose no formidable problems to the design of a protective suit for a man on the moon. The equipment specified is all well within the present state of the electronics art.

A SPECIAL KIND OF POSITION

FOR SPECIAL KIND OF MEN

To help meet the urgent and continuing problems of national security, RCA has created an Advanced Military Systems Department at Princeton, New Jersey. There, in an atmosphere of complete intellectual freedom, men of a very special kind are engaged in highly sophisticated analysis and study of our national defenses—present and future—and how they can be made most effective to meet any future enemy capability.

THE POSITION—Studies conducted by the RCA Advanced Military Systems Department are of the broadest scope and cover such diverse areas as physical and engineering sciences, military science, economics and geophysics. Accordingly, each member of the technical staff may select his own area of work. The only requirement: results must have a direct application to problems of national defense.

Each staff member is provided with every opportunity, facility and detail of environment to use his creative and analytical skills to maximum advantage and at the highest level. He has no responsibility for administrative details. He can call in any specialists he may need. He has full access to all available information—military, academic and industrial. Furthermore, specialized research projects and laboratory work can be carried out at his request by other departments of RCA.

THE MEN—The men who form the technical staff are a group of mature scientists and engineers. They are accustomed to responsible positions in industrial research, advanced development, or systems planning. Most of them have an extensive background in the broad fields of electronics, vehicle dynamics (space, marine or terrestrial), physics (astro, nuclear, or plasma), or operations research (military science). All are men who enjoy seeing the fruits of their work have a far-reaching effect on the defenses of the country.

THE LOCATION—Princeton offers unique civic, cultural and educational advantages. The RCA Advanced Military Systems Department itself occupies a new, air-conditioned building on the quiet, spacious grounds of RCA's David Sarnoff Research Center.

INQUIRIES ARE INVITED—If you are interested in learning more about this far-reaching program and the unusual opportunities it offers to qualified men, write:

Dr. N. I. Korman, Director
Advanced Military Systems, Dept. AM-1K
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To the Editor:

I have seen in M/R Oct. 12, page 43 ("More About the Missile Week") an item datelined "Cape Canaveral" reporting that the Air Force successfully launched three big missiles in 14 hours. Reading further, it seems that a Royal Air Force crew launched one of the three.

Presumably your printer dropped an "s" from Air Force.

While we appreciate that the U.S. Air Force makes every effort to launch missiles successfully, in the interests of our morale it is requested that you do not assume that the Royal Air Force is a part of the U.S. Air Force.

C. F. Hobbs
Bytown Inn
O'Connor & Albert Sts.
Ottawa, Ontario
Canada.

M/R dropped language, made no such assumption.—Ed.

Telemetry Revisited

To the Editor:

Your article "What's Wrong in Telemetry?" (M/R 10/5/59) was most interesting. I cannot help but wonder, however, why no mention of **Data-Control Systems, Inc.?** Of 24 companies named, it is our belief we shipped more telemetry equipment the past calendar year than sixteen of them. You cite the *Minuteman* PCM contract but fail to mention that DCS received the FM/FM ground telemetry contract for the missile.

Further, you refer directly to our company's recently announced development of a "Frequency Translation System."

Further, at the recent telemetry show in San Francisco, DCS exhibited the first truly operational solid-state, high-performance discriminator.

Further, our personnel will author a significant portion of a definitive handbook on telemetry now being prepared by a major publisher.

Further, I am sure members of our engineering department would make anyone's "Who's Who" of telemetry equipment designers . . .

Further, we are one of the few companies to offer a complete line of ground and airborne equipment. We also conceive, fabricate and install complete airborne and ground systems.

We think we at least rate a mention.

Robert J. Jeffries, President
Data-Controls Systems, Inc. and
over 250 chagrined employees.

To the Editor:

We at **Texas Instruments** heartily concur with the remark in the "What's Wrong in Telemetry?" article, stating: "Boiled down, it simply means that one doesn't always know what either of the other two are doing." Except that we would expand this state of confusion to include harassed editors. Though not mentioned in this round-up article, TI is certainly a mainstay of the telemetry business. Consider, as an indication, the following systems being built for the missile industry by TI: **Boeing:** *Bomarc A,* Model "C" 45-channel PDM/FM/FM telemetry system. First transistorized telemetry system in quantity production—anywhere. **Temco:** *Corvus,* 90-channel PDM/FM/FM telemetry system transistorized except for SCO's and transmitter final stages. **McDonnell:** *SR138,* modified *Bomarc* system, PDM/-FM/FM. **Convair:** *Centaur,* FM/FM, telemetary systems. Extreme reliability requirements. Completely transistorized except for power stages of transmitters.

In addition to complete systems, TI is supplying important subsystems on the following: **Martin-Denver:** *Titan,* complete signal conditioner system. **Martin-Orlando:** *Pershing,* signal conditioners. **Boeing:** *Minuteman,* 90-channel, low-level PDM system. **McDonnell-Collins:** *Mercury,* RF package (two transmitters and two power supplies).

And supporting these activities in systems and subsystems, TI has an aggressive components and equipments development program under way. Products of this program now in use are transmitters, SCO's PDM keyers, solid-state commutators, all types of signal conditioners, transistorized choppers, etc. Other programs nearing completion or awaiting appropriate applications are low-level electronic commutators, investigations of practical high-frequency equipments, digital (PCM) telemetry systems and equipments, and deep space tracking, navigation and communications equipments.

We appreciate the problems of achieving completeness in any editorial "round-up" type feature.

R. J. Mitchell
Data Presentation Manager
Apparatus Division
Texas Instruments

To the Editor:

In reading your article titled "What's Wrong in Telemetry," we were a bit disappointed to see that **Dorsett Laboratories, Inc.,** of Norman, Okla., was not listed among the Who's Who in the Telemetry Field.

We don't claim to be a pioneer in the telemetry systems and components business, but the past few years have proven us to be a strong contender. Our experience ranges from balloons to the *Mercury* capsule.

Two recent accomplishments of possible interest to your readers are: Dorsett was chosen to supply telemetry systems for experimental **Ryan** Q-2C drones, as well as the production Q-2C drone. These systems were specified to meet the rugged MIL-E-5272 environmental specification. And, also, the fact that at least three firings of the NRL *Nike-Asp* sounding rocket will be made with a 3-lb., 8 channel system, built by Dorsett in a cylindrical configuration using transistorized subcarriers and featuring 2 watts output.

We're very much in the airborne telemetry business.

D. M. Klotz
Sales Promotion Manager
Dorsett Laboratories, Inc.

To the Editor:

In your article "What's Wrong In Telemetry?" there is no mention of **Arnoux Corporation** as a supplier of telemetering equipment. I am sure this is simply an oversight on your part, for Arnoux is a major producer of both instrumentation systems and telemetering components . . .

Two years ago, Arnoux entered the decommutation equipment field with TDS, a PAM-PDM Decom. Since that time, we have sold more decommutation equipment than all other manufacturers combined. I don't want this to be a sales pitch, but the reasons, briefly, are reliability, small size, less power consumption, less heat generation, greater versatility, ease of operation and others. The major ballistic missile and space programs are all using the TDS.

Lester Cole
Advertising Manager
Arnoux Corporation

'Selling' Missile Spending

To the Editor:

In the past (and present) issues of your fine magazine, you have editorially lamented the state of our missile program. In these editorials, you have brought forth the following facts:

The Administration lacks the necessary leadership at this time to provide a vigorous missile program.

One reason for this is that the necessary agencies lack the necessary funds to institute a crash program.

The above is due to the fact that such funding would unbalance our national budget.

The administration wants a balanced budget.

You imply (and I agree) that the reason a balanced budget is so desirable at this time is that 1960 is an election year, and the fact that the present Administration can point to a balanced budget seems to be a method of gaining votes for the upcoming candidates. Because of this, it would seem that the converse would be true; an unbalanced budget at this time would produce less votes.

Because of this attitude in Washington, we are told that many industrial leaders are resigning themselves to a period of relative inactivity until after the 1960 election.

Problem immediately evident: What can be done to rectify the situation?

You have stated the answer to the problem of "what-can-be-done-about-our-lack-of-funds?" by saying "We must get more funds."

You don't say how, other than that they must be provided for.

This solution is somewhat like the solution once given by a doctor to one of his patients. The patient complained to the doctor that after he woke up in the morning he would have a terrible headache that would last for an hour, then vanish. The doctor told him to sleep an extra hour.

Both these "solutions" are not solutions, but evasions. Or, in the case of the missiles, perhaps it would be better to state the question and the answer of funds are both too fundamental. The question should be: "what can we do to convince those responsible that the allocations of necessary funds are necessary and much more important than a balanced budget?" This shift in emphasis is important. We know the answer of where to get the funds, the question now becomes one of *how* to get the money.

The answer is to use the same instrument that is hampering the outlay of the necessary appropriations to help us get them.

The instrument that has prevented proper funding is the fear that an unbalanced budget will lose votes. What is necessary to do, therefore, is to demonstrate that a huskier missile program will gain more votes than a balanced budget. This is strictly a job of salesmanship.

It can be accomplished on two levels. One level is that which can be performed by every citizen, namely writing one's congressman, the President, etc. The other is a united industrial lobby to the same effect, favoring nobody, but pointing out the necessity of an agressive missile program.

Then, a final thing can be done: public education, industry-sponsored. The other week, *The Biography of a Missile* was presented coast-to-coast. If something similar was done over a nationwide TV net, or through a released motion picture, explaining our crying need for a united, agressive, long-range missile program, it would help bring pressure to bear in Washington for a slightly unbalanced budget at this time to insure we *have* a budget to balance a number of years hence.

Stephen A. Kallis, Jr.
447 Manning Blvd.,
Albany, N.Y.

THE GRAND CENTRAL REPORT

Grand Central Rocket Co.'s recent contribution to case bondable, high impulse propellants contains ammonium perchlorate and powdered aluminum in a tailor-made synthetic rubber based on butadiene and acrylonitrile.

This rubber has excellent physical characteristics over a wide range of temperature even when filled with a high proportion—over 80%—of oxidizer and metal fuels. The propellant itself maintains nearly the same combustion properties over a wide range of temperature. It has been loaded into multi-ton rocket motors to give an inherently reliable, intrinsically simple propulsion system for an important defensive weapon.

Grand Central Rocket's propellant research is continuing along short, medium, and long-range paths aimed at higher propellant specific impulse and density. The primary objective is to provide the advanced rocket and missile designer *on schedule* with reliable, case bondable propellants which will meet or exceed his requirements.

Whereas present-day solid propellants deliver a specific impulse of not much better than 240-245 lbf-sec/lbm, many of those which will be used operationally three to five years hence must deliver 255-265 lbf-sec/lbm. Beyond this, to meet requirements for manned escape vehicles of the next decade, Grand Central Rocket plans to have propellant systems *delivering up to 280 lbf-sec/lbm or better.* Judicious combinations of new liquid oxidizers as well as new solid fuels may be used to achieve this goal along with the needed thrust control.

To further this effort, Grand Central Rocket Co. will draw on the results of Advanced Research Project Agency contractors as well as on the research of its corporate affiliates, Food Machinery and Chemical, Tennessee Gas Transmission, Petro-Tex, American Potash and Chemical Corp., and National Distillers.

At the same time research efforts will continue on reducing the proportion of inert rocket components by improving the designs of propellant charges, nozzles, and cases.

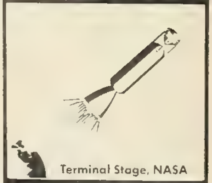
Albert T. Camp

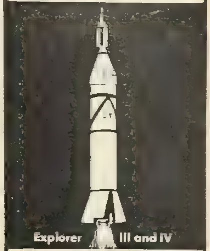
A. T. Camp, Assistant Vice President
and Director of Research

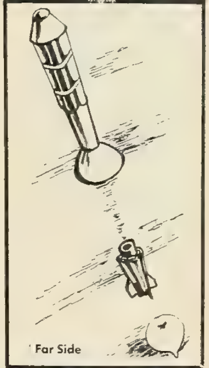
(If you have the qualifications that a fast-moving space propulsion team needs, contact our Director, Personnel. Openings now for chemists and engineers.)

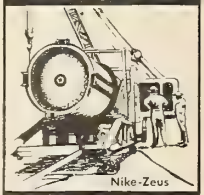
Grand Central
Rocket Co.

An Affiliate of Tennessee Gas Transmission Company
And Food Machinery and Chemical Corporation
P. O. Box 111 **Telephone: PYramid 3-2211**
REDLANDS, CALIFORNIA









Gen. Donald L. Putt, president of United Research Corp., was named 1960 president of the Institute of the Aeronautical Sciences at its recent national meeting.

General Putt, who retired in 1958 after 30 years' service in the Air Force, has held positions ranging from test pilot to Chief of Staff, USAF. At one time he was commander of the Air Research and Development Command, USAF. Following his retirement, he served as special assistant to **Dr. Theodore von Karman,** director of the National Academy of Sciences.

United Research Corp., a subsidiary of United Aircraft Corporation, is engaged in research and development in the fields of rockets and advanced propulsion systems and solid and liquid propellants. At the same time Putt became its president in 1958, he took on the duties of chairman of the Scientific Advisory Board to the AF Chief of Staff. He was also a member of the National Advisory Committee for Aeronautics for nine years.

RICHARDSON

Hughes Aircraft Company announces that **Iden F. Richardson** will be the new manager of the Hughes Products Group at Newport Beach and Costa Mesa, Calif. Richardson previously served for 23 years at Bendix Aviation Corp., where he last held the position of general manager of the Kansas City division. He holds a bachelor's degree in engineering from Purdue University and a master's in business administration from Harvard.

Richardson will replace **Raymond B. Parkhurst,** who held the position while the two manufacturing facilities were being completed. Parkhurst will resume his duties as vice president-manufacturing.

Harold R. Boyer has been elected a General Motors Corp. vice-president and General Manager of the Defense Systems Division, by the GM board of directors. Director of Military Products for GM since April, he joined the corporation in 1925 as a works engineer for Pontiac Motor Division.

From 1930 to 1940, Boyer was president and general manager of the Allen Corporation, Detroit. Before rejoining GM in 1943, he served as Chief of the Aircraft Manufacturing Branch of the War Production Board. He also served the government in 1951 and early 1952 as Chief of Aircraft Production for the Defense Production Administration.

Dr. Bernald Litman has been assigned director of the Flight Test Program for the first flight tests of the all-inertial guidance system in the Air Force *Atlas* ICBM produced by the American Bosch Arma Corp. The tests are scheduled for sometime in 1960 at Cape Canaveral.

Dr. Charles D. Bock, director of the Technical Staff in Engineering Operations, Operations, Arma Missile Guidance Department, has been assigned the responsibility for in-plant technical decisions required by the Flight Test Program.

KURTZ

Dr. Anthony D. Kurtz, former Director of Research of the Semiconductor Division of Minneapolis Honeywell Regulator Co., has been appointed General Manager and Executive Vice-President of Kulite Semiconductor Products, Inc.

In his new position, Dr. Kurtz will be responsible for research, development and production activities in semiconductor materials and devices. He received his B.S., M.S., and Sc.D. degrees from the Massachusetts Institute of Technology in the fields of physics and physical metallurgy.

He is a member of the American Physical Society, The Institute of Radio Engineers and the American Society of Metals, and has published numerous articles on solid-state physics and semiconductors.

SHELTON

Dr. Frank H. Shelton has joined Kaman Nuclear, a division of the Kaman Aircraft Corporation. He was formerly Technical Director of the Department of Defense Atomic Support Agency for four years. In this position, he coordinated the Pentagon's programs on the nuclear weapons tests in Nevada and the Pacific, directed its world-wide fallout activities, and was the scientific director of the Argus nuclear weapons tests in the South Atlantic in the summer of 1958.

Included in his experience are three years at Sandia Corporation's Nuclear Weapons Effects Division. He has also engaged in research pertaining to nuclear reactors, studies of various high temperature alloys, and cosmic ray research.

Dr. Shelton received his B.S., M.S. and Ph.D. degrees in physics from the California Institute of Technology.

Theodore J. Smith has been named Packard Bell Computer Corp.'s sales manager. Smith is a Maryland University graduate in engineering. Before joining Packard Bell Computer, he served as chief applications engineer for the Nuclear Division of American Electronics, Los Angeles, and assistant to the vice-president for engineering at Gilfillan, Inc.

Dr. Lloyd P. Smith, former president of Avco Research and Advanced Development Division and a director of Avco Corp., has joined Aeronutronic, a division of Ford Motor Co., as director of Research Operations.

He is also a member of the Advisory Committee on Grants, Research Corp., of New York City; Advisory Council, Fund for Peaceful Atomic Development, and Advisory Committee on Solid State Physics, Office of Naval Research. He is chairman of the Advisory Council of the Electrical Engineering Department; Princeton University, chairman of the Corporation Committee, Cornell University; chairman, Advisory Panel for Physics, National Science Foundation; and a member of the Research Division of the American Ordnance Association and Chairman of the Physics Section.

FRANKLIN

Robert A. Franklin, author of numerous scientific papers on electronic and nuclear subjects, has been appointed Manager of Engineering of Stromberg-Carlson-San Diego, a division of General Dynamics Corporation.

An engineering graduate of University of Washington, he also received an M.S. from the University of California. His business experience includes: staff engineer for the Submarine Signal Co.; chief of the radar section of the U.S. Navy Electronics Laboratory in San Diego; establisher of the Franklin Engineering Co., and technical advisor to the Air Force Special Weapons Center at Albuquerque. He held the position of regional manager of Radiation, Inc. Albuquerque, until his appointment at Stromberg-Carlson.

Hobart E. Switzer, has been appointed to the position of Director of Manufacturing of Interstate Engineering Corporation's Missile Division, Anaheim, California. **James R. Day,** who was associated with the late **Major E. H. Armstrong** in the development of wide-band frequency modulation, has been elected a director of Radio Engineering Laboratories, Inc., communications subsidiary of Dynamics Corporation of America.

Robert F. Halligan has been named executive vice-president and general manager of The Hallicrafters Company. **Ivar C. Peterson,** will assist the president of Lear, Inc. in directing and supervising technical planning.

propulsion engineering . . .

By JAY HOLMES

Two electrical propulsion schemes . . .
now show promise of being ready for use by the time we need them—when we develop reliable boosters for manned space vehicles and satellites weighing 10,000 pounds and up. Both ion and arc-jet (also called plasma jet) rockets are low-thrust, lightweight long-duration systems far superior to chemical and nuclear propulsion for maneuvering in space.

But the two fill different missions . . .
The ion rocket, although its specific impulse is higher, has a much lower thrust-to-weight ratio. The arc-jet has a lower I_{sp} and a higher thrust-weight ratio. Thus the arc jet occupies a position between the ion rocket and the conventional systems.

Plasmadyne Corp. plans soon to build flyable arc-jet motor with a thrust of about 20 lbs. and I_{sp} of 1500 to 2000 seconds. There is hope that a nuclear powerplant may be available by 1965 to make possible an arc-jet system with thrust-weight ratio of 4 or 5 x 10^{-14}.

Ten days to two weeks . . .
would be needed for an arc-jet propelled moon trip. This is the time needed to lift from a 110-mile earth orbit. With suitable guidance, the arc jet could maneuver the vehicle into a moon orbit and return. But it would have too little thrust to be used for a soft landing.

Because its thrust is higher than an ion rocket, the arc jet also might be preferred for powering a manned satellite to a higher orbit. The maneuver would take less time, which might be limited by supplies of food, water and air.

Ion propulsion is preferred for longer missions . . .
such as the trip to Mars. On a trip that might take almost a year it makes relatively little difference whether the total work is performed rapidly with a high thrust or slowly with a low thrust.

For example, if we do all the work in a few seconds by burning a high-thrust final-stage chemical rocket, the trip to Mars might take 240 days, assuming specific impulse of 400 seconds. But the payload fraction would be less than 25%.

The trip would last 10 or 20 days longer . . .
with an arc jet, specific impulse 1500-2000 seconds. But the payload fraction rises to about 30%.

Now let's see what happens when we switch to ion propulsion. Specific impulse increases to 4000 seconds. However, the thrust drops sharply. The most powerful ion engine now in existence generates only 2 lb. The length of the trip to Mars by ion propulsion may be 300 days. But now we have a payload fraction of more than 50%. Obviously, it may often be worthwhile to make the trip a little longer and get the big payload increase that goes with it.

Shifting orbits for unmanned satellites . . .
is another mission for ion propulsion, even though the arc jet can do it faster. Here, it may not be important that several weeks are required to lift a 110-mile satellite to a 24-hour orbit. The important factor may be the lighter weight and higher specific impulse of the ion system. This may also be true of shipping freight to a moon base.

Both ion and arc-jet propulsion . . .
can be available soon. T. M. Littman of **Rocketdyne** predicts that the first-generation ion engine will be ready for flight test in two or three years. The arc jet will follow soon behind. Both have great potential. But both are limited by a bugaboo that hampers every propulsion system in existence—the availability of materials that will withstand the high temperatures involved.

Come back next week for a few possible answers to this problem. The entire Nov. 23 issue of M/R will be devoted to Space Age materials.

reviews

MATERIALS IN SPACE ENVIRONMENT: PROCEEDINGS OF THE FIFTH SAGAMORE ORDINANCE MATERIALS RESEARCH CONFERENCE, Office of Ordnance Research, U.S. Army, Sept. 1958. Order PB 151900 from OTS, U.S. Dept. of Commerce, Washington D.C. 276 pp. $4.

This conference, held in September 1958, dealt with the problems of materials in the space environments encountered by space vehicles or orbiting satellites.

Participants were government, industry, and university representatives, all connected with some phase of metallurgical research or applications related to the field. Space environment phenomena were considered along with their effects on materials.

The report contains 18 papers, some formal lectures, others transcripts of informal discussions.

General subjects covered are: "Space Environment and Vehicle Requirements," "Physics of Space Vacuum and Effects on Materials"; "Thermal Problems under Orbiting Conditions"; "Radiation and Radiation Effects in Outer Space"; "Meteorites and Cosmic Dust in Space"; and "Implications of Space Environment for Material Development."

THE SERVO ENGINEER'S HANDBOOK, Daystrom Transicoil, Division of Daystrom Inc., Worcester, Pennsylvania. 128 pp. $3.

Devoted exclusively to servo components, the book deals with the individual components—how to use them, how not to make them. Although the basic theory is presented, the overall treatment is practical rather than classical.

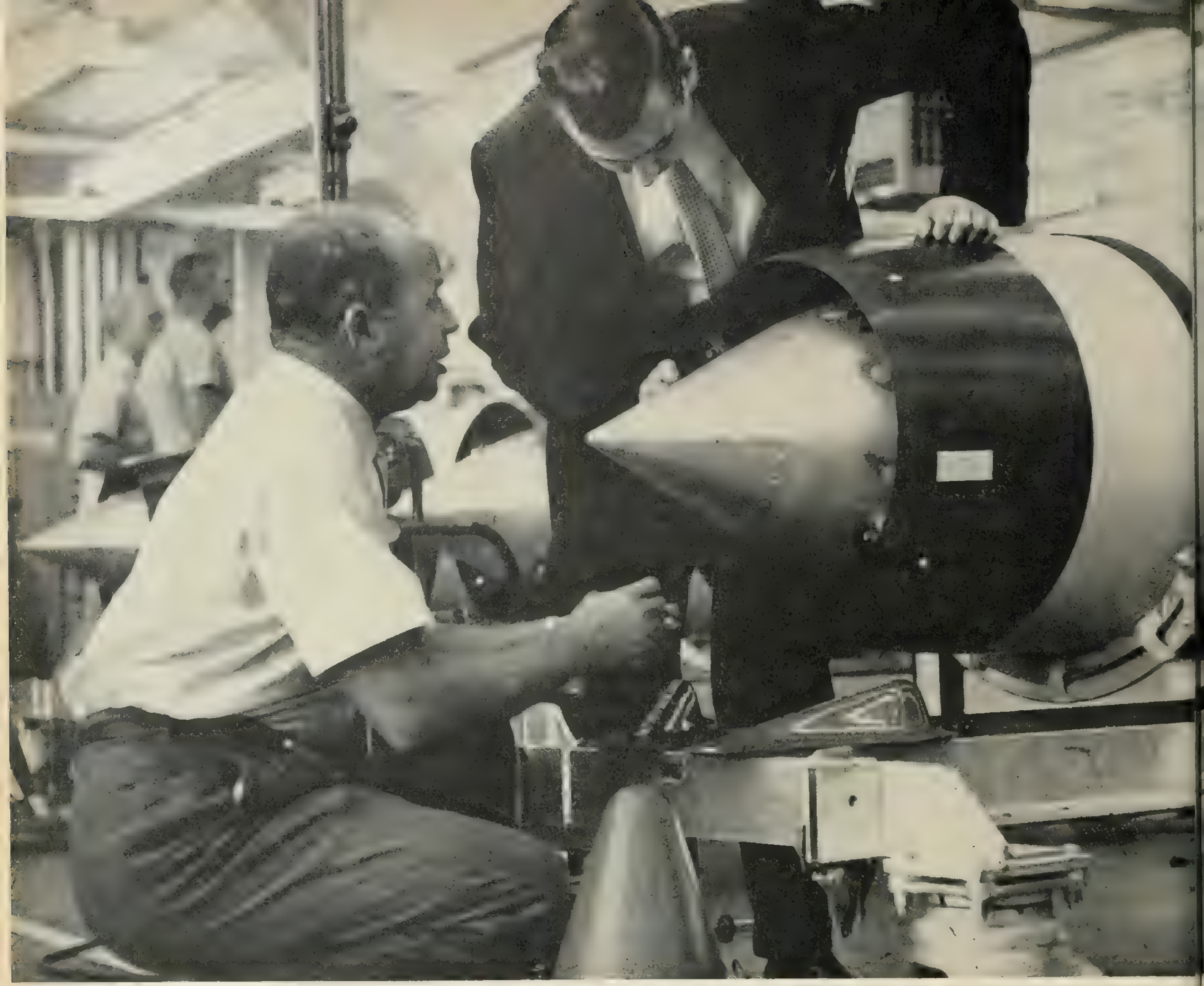
The contents include: Introduction to servomechanisms, Servo Motors, Rate Generators, Synchros, Gear Trains, Servo Amplifiers, Servo-System Engineering and Environmental Testing.

STUDY OF THE WELDABILITY OF ALUMINUM CASTING ALLOYS WITH 5086 WROUGHT ALUMINUM ALLOY, M. S. Orysh and I. G. Betz, Frankfort Arsenal, U.S. Army. Order PB 151307 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 55 pp. $1.50.

This study was conducted to determine the weldability of the 5086 alloy to selected cast aluminum alloys. Inert gas shielded metal-arc welding was used.

The study demonstrated that thin weldments, welded without a backing strip, are more apt to have very poor joint strip efficiency because of lack of fusion. An experimental perforated weld test used with grid lines proved to be a useful tool for determining weld ductility.

The moderate strength, good formability, excellent resistance to general and stress corrosion, and weldability of 5086 wrought aluminum alloy sheet make the material promising for use as skin for ballistic missiles, the study showed.



RAMJET LEADERSHIP—Ken Hisey (left), Superintendent, Propulsion Shops, discusses some of the finer points of one of the many Marquardt engines with Frank McGuire of the editorial staff of Missiles and Rockets magazine. The pioneering of higher performance ramjet engines by Marquardt has vastly increased the defense area of the advanced Bomarc missile.

WHO READS MISSILES AND

Well, for instance . . . TOP ENGINEERS AT MARQUARDT

Accelerated developments in air-space research . . . advanced power systems . . . manufacturing . . . space-age training . . . and research rocketry have made The Marquardt Corporation one of the foremost leaders in the field of astronautics.

The Marquardt ramjet engines, for example, have been actually flight tested at speeds well over Mach 4 at an altitude of 80,000 feet. Continuous ground cell endurance tests have been successfully conducted to simulate even greater altitudes and higher speeds. In addition to the development and production of propulsion systems that will operate at supersonic speeds, Marquardt has also been a leader in the development and application of high temperature metals and reinforced refractory ceramic coatings for future missiles.

Precision controls and rotating accessories for space vehicles are still another facet of The Marquardt Corporation. A few of these are . . . precision controls for ramjet engines . . . rotating accessories for pneumatic servo actuators . . . and air inlet controls for North American Aviation's "Hound Dog" air-to-surface missile. New and superior production line techniques have been installed at Marquardt's Ogden Division to more than double the production capacity of Bomarc ramjet engines—yet with 100% reliability.

Marquardt is also taking a giant step into tomorrow with ASTRO—Air-Space Travel Research Organization. ASTRO has its own aerodynamic test facilities that are capable of approaching the speed of Mach 12 and temperature tests at approximately Mach 7 (3700° Fahrenheit). Also included in Marquardt's

"Development of products in today's space age is a complex business requiring vast engineering and scientific technology. Additionally, information concerning latest developments in our industry is essential. Missiles and Rockets helps us keep pace in this rapidly expanding market." Don L. Walter, Marquardt Vice President, Power Systems Group.

"Today's missile engineers are comparative youngsters with an unending thirst for knowledge of the entire astronautics market. Missiles and Rockets gives us a total, uncluttered picture of what's going on in this field from week to week!" John Widell (left), Project Engineer, Propulsion Engineering.

"If you want pears, you don't order fruit salad. The same holds true in astronautics. We prefer Missiles and Rockets magazine because it deals with astronautics and astronautics *exclusively*." Dick DeSantis (right), Supervisor of Numerical Analysis Section.

ROCKETS?

diversified activities is the manufacture of ground support and handling equipment for missiles . . . systems engineering and equipment for data display . . . development and production of rocket systems . . . specialized solid rocket motors and components for space and missile systems. Marquardt recently established a Nuclear Systems Division in the Power Systems Group. Project Pluto is one of their major programs — aimed at the development of a nuclear ramjet engine.

TELL YOUR PRODUCT OR CAPABILITY STORY TO 29,000 MISSILE TECHNICIANS. . . PAID SUBSCRIBERS . . . THROUGH THE PAGES OF MISSILES AND ROCKETS—TECHNICAL/NEWS WEEKLY OF THE MISSILE/SPACE MARKET.

"The missile engineer must have frequent, technical news concerning the industry. That's why the *weekly* issues of Missiles and Rockets are so important to us. Month old news is of little value when yesterday's developments could easily be obsolete tomorrow." Leigh Dunn (right), Director, Test Section.

M/R

missiles and rockets

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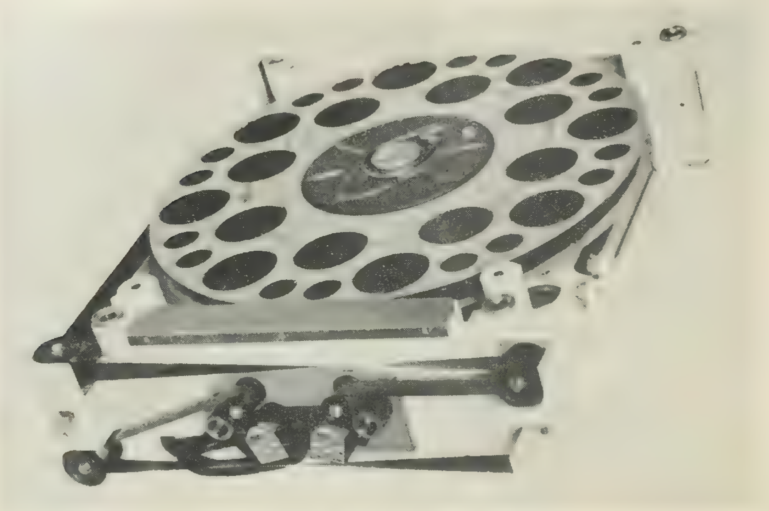
1001 VERMONT AVENUE, N. W., WASHINGTON 5, D. C.



Unit to Record Astronaut's Voice

A 12 lb. tape recorder (including 4800 feet of magnetic tape) will record the environment of the nation's first manned orbital space flight, the physiological effects on the astronaut making the historic flight, and his voice comments.

The **Datalab Division** of **Consolidated Electrodynamics Corporation** has revealed details of the satellite magnetic tape recorder that it designed, developed and manufactured under a $135,480 contract award from **McDonnell Aircraft Corp.,** capsule contractor for the National Aeronautics and Space Administration's Project *Mercury*.

Besides the voice commentary of the Astronaut in the space capsule and phenomena detected by sensitive pickups taped to his body, the tiny data acquisition system will also monitor such environmental conditions as temperatures, pressures, acceleration and shock.

Design goals of the magnetic tape recorder were to achieve a combination of minimum size, minimum weight, minimum power consumption and high reliability. Datalab engineers delivered a unit that weighs only 9 lbs. without tape, measures only 11 x 13 x 3-5/8 inches complete with electronics, requires less than eight watts of power, and has excellent characteristics of performance and reliability.

To provide the smallest volume the recorder has been designed with takeup and supply reels on opposite sides of the main casting. Associated record electronics, drive motor, and integral gear trains are mounted on the central casting between the two reels.

Power consumption was minimized by the use of specially designed "wraparound" dual capstans. The tape wraps around 270° of the capstan to obtain driving friction, eliminating the customary solenoid-actuated pinch rollers. Elimination of pinch rollers components reduced weight; precise tape tracking was obtained by the absence of pinch roller tape deformation.

The two record heads are mounted on a precision plate assembly on the side edge of the main casting. Tape passes over them as it moves from one side to the other. A slight speed differential between the takeup and supply capstans maintains a constant tension on the tape as it moves across the two heads.

The recorder designed for the *Mercury* project will have a tape speed of 1 7/8 inches per second. A kit can convert the speed to 15 ips if desired. The system will make possible eight hours of continuous recording on the .65-mil tensilized Mylar tape of ½" width.

On the magnetic tape will be one channel of voice communication from the pilot and up to six channels of multiplexed analog data from appropriate record amplifiers. Other electronics include a bias oscillator for analog recording.

At 1 7/8 ips the wow and flutter of the tape recorder will be less than 1% peak-to-peak between DC and 500 cycles per second.

In selecting materials from which to build the magnetic tape recorder engineers had two criteria. The materials had to be as light as possible, and had to be inorganic to preserve the precious supply of oxygen aboard the space capsule. The main casting is a magnesium alloy of thin section design. Magnesium reels combine rigidity with light weight. Special paint, insulation and drive belt materials were used. Drive belts are of especially compounded silicone rubber.

The tape recorder will be required to operate in the varying conditions of launch, orbit, and re-entry. The operational environmental specifications are temperature range, –15 to +200°F; vibration, ±10 g from 5 to 2000 cps; continuous acceleration, ±6 g's in all axes; and shock to 100 g.

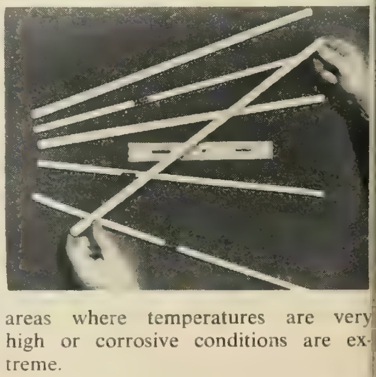
Tapes produced on the airborne recorder will be played back on a standard reproducer using a special adapter supplied with the recorder for matching the hubs to standard NSRTB reel hubs. Engineers will have for their study a complete analog record of all phenomena that occurred on the historic flight.

Consolidated Electrodynamics Corp.
360 Sierra Madre Villa
Pasadena, Calif.

Ceramic Tubing Resists Shock, Ultra-High Temps

Beryllium oxide ceramic tubing in lengths to 24 inches, highly resistant to elevated temperatures and to thermal shock, is available from **National Beryllia Corp.**

Berlox beryllium oxide tubing is supplied with both ends open or with one end closed, for insulation and protection of thermocouples and other sensing and measuring elements for use at extremely high temperatures or where heavy radiation is encountered. Berlox tubing is also used to introduce materials to, or draw samples from, areas where temperatures are very high or corrosive conditions are extreme.



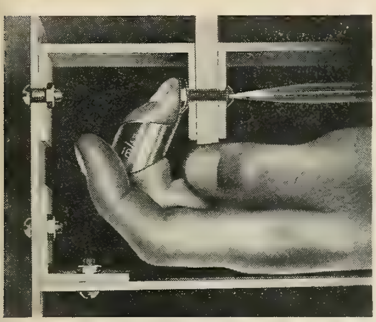
Properties of Berlox tubing include melting point of 4650°F, greater strength above 2000°F than any other known ceramic, high hardness and abrasion resistance, high electrical resistivity combined with high thermal conductivity, and immunity to heavy doses of radiation. The exclusive high-fired surface is permanently dust-free, thus eliminating toxicity problems. Because of high density, the tubing is essentially gas-tight.

Round, single-bore tubing is available from stock in lengths to 21 inches, and to 24 inches on special order. Standard sizes are 5 (ID) x 7 (OD) mm, 1/4 x 3/8 in., 3/8 x 1/2 in., and 7/16 x 11/16 in. Special insulator tubing, round or oval, is available in stock lengths of 6 and 12 in., with single or twin bore, in sizes from 5/64 to 3/16 in. OD and bores from 3/64 in., Berlox tubing custom-made to non-standard lengths, diameters and bores is available on 4-to-6-week delivery.

National Beryllia Corp.
4501 Dell Ave.
North Bergen, N.J.

Finger Tool Reaches Remote Working Areas

A finger tool design that enables the user to reach into snug, narrow, remote or hidden working areas—to "Touch 'n Hold" a nut or bolt in a true fixed position for assembly or disassembly—is available from the **Beaver Tool Co.**



The "Touch 'n Hold" tool is a wrench which is worn like a ring on the finger without restricting the free motion of the hands or fingers. It is adjustable to fit different size fingers. These finger wrenches are supplied in the most popular Hex Head nut sizes.

Beaver Tool Co.
Box 256
Huntington Station, N.Y.

Small Unit Does 100,000 Calculations Per Minute

A small transistorized scientific computer which can perform more than 100,000 calculations a minute was announced today by the **Data Processing Division** of **International Business Machines Corporation.**

Requiring little more space than the average desk or drafting table, the new IBM 1620 Data Processing System operates under the direction of an internally stored program of instructions. It can perform complex engineering and scientific computations on a continuous or production basis.

Advanced features incorporated in this compact but powerful computer include 20,000 digits of magnetic core storage with variable field length and immediate accessibility, and paper tape and electric typewriter input and output. The availability of two advanced programming systems and a comprehensive library of mathematical and statistical routines simplifies programming for the 1620. Specific programs for the petroleum industry, public utilities, civil engineering, and optical firms will be available.

International Business Machines
Data Processing Div.
112 East Post Road
White Plains, N.Y.

Glass-Epoxy Laminate Takes High Temperatures

A new glass-base, epoxy-resin laminated plastic for use in both normal and elevated temperature applications has been announced by **Taylor Fibre Co.**

Designated as grade GEC-111, the new laminate meets the specifications for NEMA grade G-11 and military grade NIL-P-18177B-Type GEB. A one-eighth inch thick sheet of GEC-111 retains at least 68% of its flexural strength after one hour exposure at 300°F, thus exceeding the military specification of 50% strength retention under those conditions.

The ability to retain strength at elevated temperatures makes GEC-111 particularly suitable for use as the base material for copper-clad laminated plastics. Printed circuit boards made from GEC-111 copper-clad laminates will not distort when placed in solder baths.

The material's excellent strength retention also suits it for use wherever high ambient temperatures are encountered such as might occur in miniaturized, enclosed components. Its maximum heat resistance for continuous use is 350°F.

As is characteristic of other glass-epoxy laminated plastics, GEC-111 combines extremely high flexural, impact and bonding strength with low moisture absorption and excellent chemical resistance. Because of its low moisture absorption it exhibits low dielectric losses and good insulation resistance even during exposure to high humidity.

Taylor's Grade GEC-111 is furnished in sheets only in a thickness range of .010 to 1 inch inclusive. Sheets up to 3/32-inch thick may be cold punched. The copper-clad laminate is supplied either with rolled copper foil (GEC-111R) or with electrolytically deposited foil (GEC-111E). The bond strength of copper foil to the base is from 8 to 10 pounds per inch of foil width, depending upon the type and thickness of foil.

Taylor Fibre Co.
Norristown, Pa.

Coating Provides Temp Control for Space Units

A team of **Bausch & Lomb** scientists has delevoped a thin film coating which provides a means of temperature control for the electronic system of satellites. The coating, which covers the satellite's solar batteries, reradiates heat into space. It provides an external cooling system which reduces the equilibrium temperature of the satellite operating in the presence of high-intensity sunlight encountered at great altitudes.

Intense heat from the sun not only reduces the efficiency of electronic gear for radio transmission from satellites operating in outer space, but may even melt the solder fittings which link the batteries together, thus ending all further radio contact. Basic research on the coating was conducted by Dr. J. F. Hall, Jr., Project Physicist in the B&L Vacuum Coating Department.

Silicon solar cells are often used as an electrical power source for satellites and other space vehicles. The solar cells are fitted to a large portion of the external surface of the satellite, and absorb most of the sun's energy which falls upon them. Only about 10% of this energy can be used to produce electrical power; the remaining radiation basically heats only the battery cells and the satellite itself. Under these conditions, the only effective means of "cooling" the solar batteries is by reradiating the sun's energy back into space, after it hits the satellite.

The thin film, which was developed

to provide this unique cooling system, was a direct result of a request from the Astro-Electronic Products Division, **Radio Corporation of America,** to produce a satisfactory means of providing a temperature control for the satellite's covering of batteries. Dr. A. F. Turner, head of the B&L Vacuum Coating Department, coordinated the research and development program within the specifications.

Working on the data provided by Dr. Turner, Dr. Hull and R. E. Peo developed a film coating composed of magnesium fluoride and silicon monoxide. The coating, which is less than 2.5 microns thick (approximately one ten thousandth of an inch), keeps the solar batteries "cool" by reradiating the long wavelength "heat rays" away from the satellite. At the same time, the film coating allows the cells to absorb the shorter radiation necessary to produce electrical energy.

Turner and Hall point out that the effective protection which this new coating now supplies may mean the difference between losing radio contact with the satellite after a few hours or days, and having radio reception remain intact, theoretically, for as long as the satellite itself remains in orbit.

Bausch & Lomb Optical Co.
Rochester 2, N.Y.

ROCKET CONTROLS ENGINEERS

1) For development and analytical design of valves and controls for rocket engine systems. Develop specification requirements for components covering design, test and development. Prepare data for proposals. BS in ME or AE and 3-7 years experience with hydraulic pneumatic devices and systems.

2) For dynamic analysis of mechanical systems associated with rocket propulsion. Mathematical descriptions of controlled rocket components with regard to systems stability. Interpretation of designs for controlling rocket components. Analogue simulation of systems. Supervision of above area. BS, ME or EE. Experience in servo systems analysis and techniques.

To arrange interview call collect, Niagara Falls BUtler 5-7851, or send resume to:

SUPERVISOR ENGINEERING EMPLOYMENT

BELL AIRCRAFT CORPORATION
Buffalo 5, New York

Tiny Rate Gyro Made For Research Rockets

A new gyro for high-altitude rocket research has been announced by **Humphrey, Inc.** The gyro, known as model RG24-0103, is only 1 5/8" in diameter and 3½" long, including the **Bendix** connector.

Despite its extremely small size, it has a DC motor and potentiometer pickoff. This is said to be the smallest precision DC gyro with pot pickoff ever made for high-altitude use.

The new Humphrey instrument is hermetically sealed in a steel case. It withstands rugged environmental conditions, such as temperature from −65° to +180°F, unlimited altitude, vibration of .06 DA to 10 g, whichever is limiting, 10 to 2000 cps, shock of 75 g for 6 to 12 milliseconds on any axis. The gyro can be provided with output potentiometer values to meet any of the usual requirements. The motor runs on 28V DC, 150 ma maximum running current.

Humphrey, Inc.
2805 Canon Street
San Diego 6, Calif.

Bleeder Cloth, Parting Film Duties Combined

A combination bleeder cloth and parting film is now in volume production at **Narmco Resins & Coatings Company.**

The new material, labeled Ventcloth by the manufacturer, combines the function of a parting agent (such as cellophane, polyvinyl alcohol, silicone or wax) with that of a bleeder cloth. The latter is required in vacuum-bag molding operations whenever a large laminate area is being cured and there is a chance that the vacuum will not draw out all of the air across the entire surface. The parting agent, in turn, is used to prevent the cured laminate from adhering to the bleeder cloth or the vacuum bag itself.

The new cloth consists of a woven glass fabric impregnated with a parting agent. It is laid directly over the final laminate layer just before the vacuum bag is used to cover the assembly. As vacuum is drawn, air trapped under the bag surface escapes through the porous material layer. The Ventcloth remains porous and open throughout the cure cycle, ensuring laminates that are virtually void- and air-free. Moreover, since all air is removed, it insures that full atmospheric pressure will be applied to all parts of the laminate. Shop experience indicates that this will increase resin flow by as much as 15%, resulting in a more dense and uniform laminate structure.

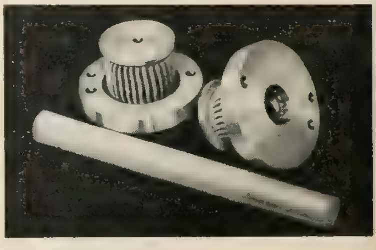
Narmco Resins & Coatings Company
600 Victoria Street
Costa Mesa, Calif.

Filter Called World's Tiniest with Relief Valve

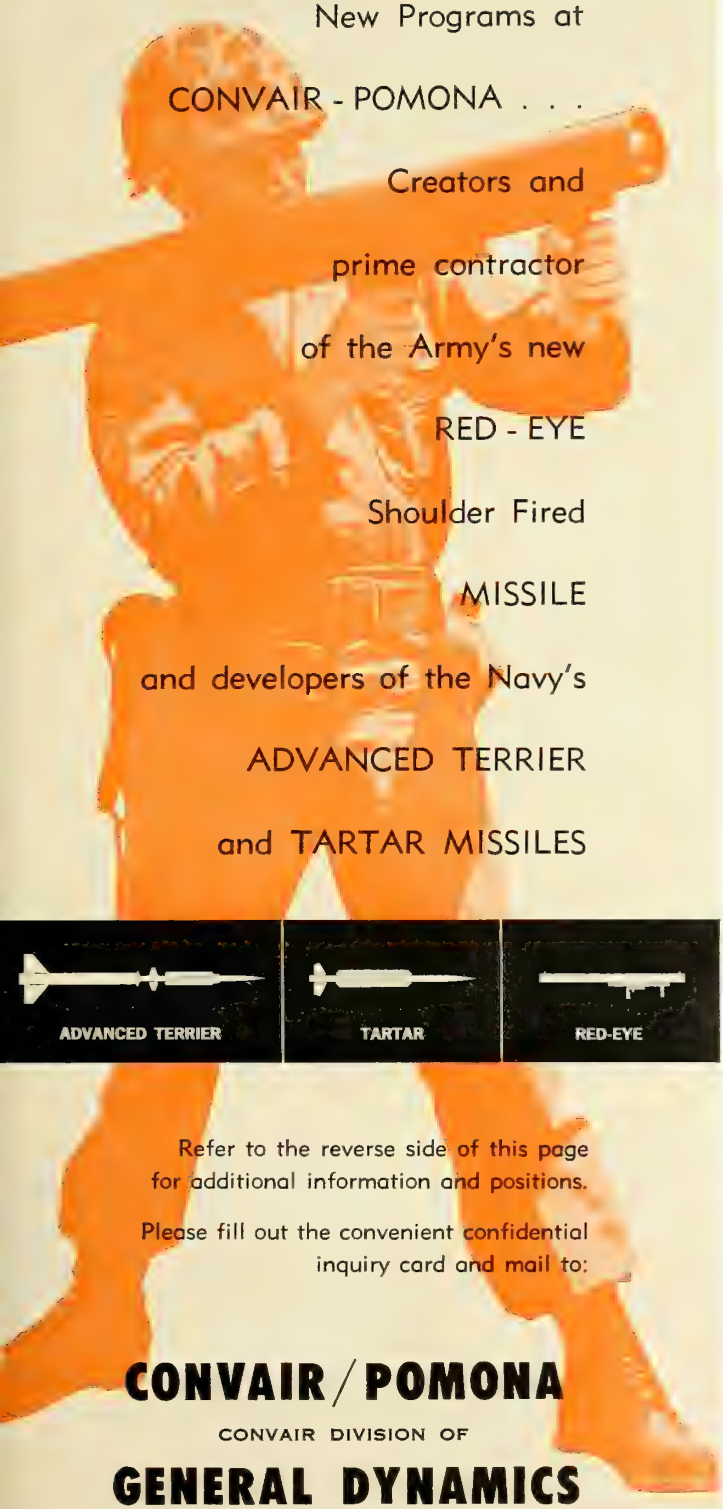
The world's smallest precision filter with a relief valve is currently being manufactured by **Aircraft Porous Media, Inc.,** the company says. The unit, which weighs only 1.18 oz., is rated at 2 microns, and at 15 microns absolute.

The filter is designed to operate at 0.3 gpm under normal conditions, and at 0.8 gpm under intermittent surge. It has a temperature range of −65°F to 275°F. Relief valve cracking pressure is 150± 15 psi. Materials used are all stainless steel.

Originally designed for use on a pump for hydraulic oil (MIL-H-5606), the filter can be used with other fluids, including corrosives, and with gases. The filter element is made of corrugated SUPRAMESH.



Aircraft Porous Media, Inc.
Glen Cove, N.Y.



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POMONA, CALIFORNIA

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If you are a qualified engineer or scientist, we urge your prompt inquiry on the attached Professional Employment Inquiry form. Interviews in your area will be arranged for qualified applicants.

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CONVAIR DIVISION OF

GENERAL DYNAMICS CORPORATION

POMONA, CALIFORNIA

—more about the missile week

• **Wallops Island, Va.**—An Army research rocket—the five-stage *"Strongarm"*—probed 1050 miles into the upper atmosphere Nov. 10. The vehicle, composed of an *Honest John,* two *Nike-Ajax* boosters, a modified *Recruit* and a scaled-down *Sergeant,* put up an instrumented nose cone which gathered ionization data to be utilized in the ICBM and *Nike-Zeus* anti-ICBM programs.

• **Vandenberg AFB**—An electrical system malfunction caused the fourth straight failure Nov. 8 in Air Force attempts to recover an instrumented capsule from a polar-orbiting *Discoverer VII* satellite. The malfunction cut off power to actuate the separation sequence as well as to the vehicle stabilizer.

• **Washington**—Appointment of Dr. Charles L. Critchfield to head ARPA is being investigated by the House Military Government Operations Subcommittee on grounds of possible conflict-of-interest. It was disclosed that Critchfield would continue to draw a $35,000-a-year salary from **Convair** while serving in the Pentagon post without compensation (WOC). The subcommittee plans to look into all DOD WOC personnel, including hundreds of consultants, as well.

• **Huntsville**—A training program for troops who may eventually man the *Nike-Zeus* AICBM is being developed at the Ordnance Guided Missile School. Representatives of 21 Army agencies and the contracting team headed by **Western Electric** have held three secret sessions.

• **Washington**—Missile industries in the news: **Telecomputing Corp.,** Los Angeles has purchased for more than $2 million the **Monrovia Aviation Corp.,** a wholly-owned subsidiary of **Carrier Corp. Minneapolis-Honeywell Regulator Co.'s** semiconductor division will build a $1 million R&D center at Riviera Beach, Fla. . . . **Minneapolis-Moline Co.** has acquired **Hymac Electronics,** Culver City, Calif.

• **Des Moines**—The Army disclosed that Baker, the 1-lb. rhesus monkey which survived a *Pioneer IV* shot May 28 to an altitude of 360 miles, is expecting a baby. Arrival date unspecified.

• **Washington**—Contract for joint Army-Navy-Air Force Power Information Center probably will be let in January. The center, to be established by Interservice Group for Flight Vehicle Power, will act as coordinator for all technical information concerning R&D in power and energy sources (exclusive of propulsion). Primary concern is energy conversion for space—thermoelectrics, thermionics, fuel cells, etc. (Mission and organization of Interservice Group as well as a comprehensive survey of government agencies involved in this work will appear in the Nov. 30 M/R.)

• **New York—General Dynamics Corp.** reports nine-month net profits to Sept. 30 of $16.8 million on sales of $1.2 billion compared to a net of $28.7 million on $1.2 billion sales for the like 1958 period. Write-off of the Convair 880 jet transport program was attributed to the decline.

• **Seattle—Boeing Airplane** reports nine-month sales of $1.1 billion and net earnings of $8 million and predicts an improvement in earnings during the final quarter. Its Sept. 30 backlog stood at $2.2 billion.

• **Burbank, Calif.**—A net for the nine months ended Sept. 30 of $6.2 million was reported by **Lockheed Aircraft Corp.** on sales of $939 million. Almost two-fifths of sales were from missile and space work.

Mergers & Expansions

For an exchange of stock, **Fairfield Engineer Corp.,** Springdale, Conn., has acquired **Cove Industries Inc.,** Norwalk, Conn. Fairfield makes magnetic amplifiers . . . **Del Mar Engineering Laboratories,** Beverly Hills, Calif., has purchased **Electromation** of Santa Monica and will operate the company as a subsidiary for development of missile subsystems . . . **Litton Industries** now has a majority interest in **Svenska Dataregister,** Stockholm cash register maker . . . **Universal Controls'** subsidiary—**C. P. Clare & Co.**—is doubling its relay and switch production space at Chicago . . . At Zug, Switzerland, **Varian Associates** has formed a European subsidiary. A research and applications laboratory will be maintained at Zurich . . . **Capehart Corp.,** which recently acquired **Dynamic Electronics,** is re-activating its military-industrial division . . . and **Infrared Industries,** Waltham, Mass., has formed a new photoconductor and a new controls division.

About the Cover

En route to service aboard fleet ballistic missile submarines and in storage, *Polaris* missiles are protected against shock and vibration by an air-suspension system. A prototype of the shipping container developed by **Goodyear Aircraft's Arizona Division** on the cover of this week's issue of M/R shows the system of log-type spring units to hold *Polaris* with a "soft touch."

Polaris container designs have a high energy absorption factor with sprig efficiencies reportedly as high as 85%. Goodyear says when containers are subjected to 30 g's impact, air suspension attenuates the loading on missile to 4 g's.

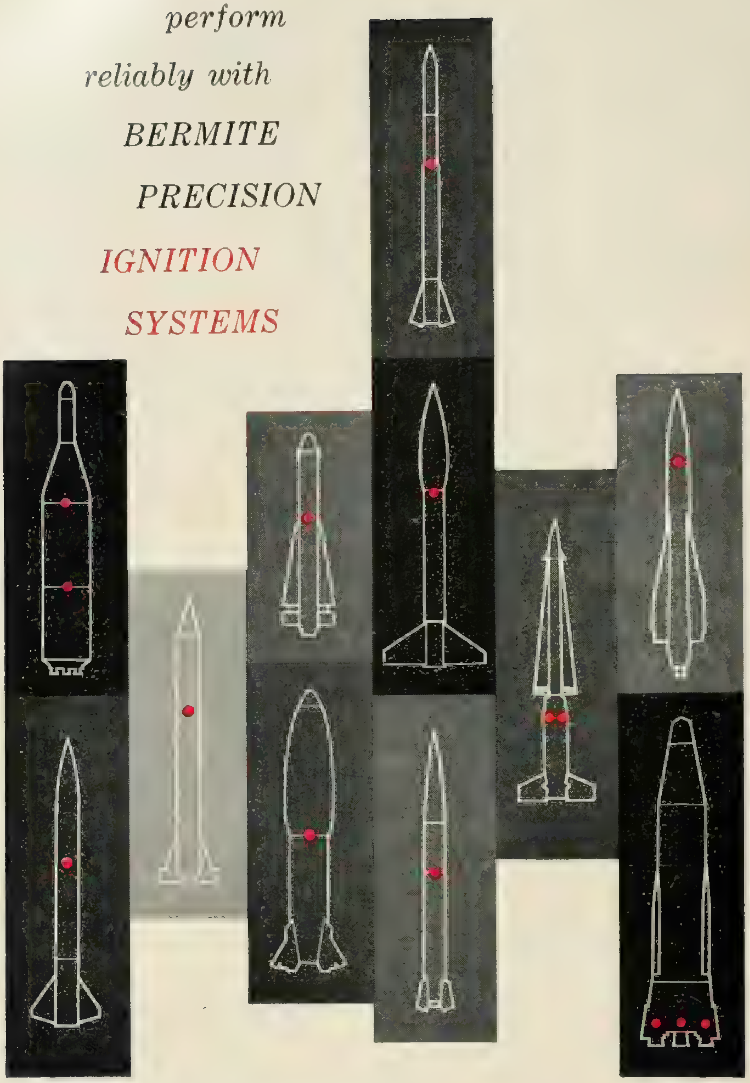
Next Week's Special Issue

Next week, MISSILES AND ROCKETS *presents a historic first—a symposium on needs now and over the next decade in materials for the Space Age.*

Staff-written articles will outline major problem areas in research, high-temperature and high-strength structures. For additional information, M/R went to the men who know material needs best—those who are developing materials for the prime and propulsion contractors on America's most important missile and space vehicle systems. A special section, entitled "Missile Makers Speak," will include statements on materials by spokesmen for 12 major contractors.

Will these needs be met? M/R asked this of material suppliers. In a second special section, "Missile Suppliers Speak," top engineers for 45 companies state their views on such topics as refractory metals, ceramics, plastics, coatings, and metal working. In the latter category will be statements on welding, forging, deep drawing, spinning, turning, casting and hollow-core construction. And there will be an article on an exciting new process—explosive forming—by a top expert, Dr. John S. Rinehart of the Colorado School of Mines.

rockets perform reliably with BERMITE PRECISION IGNITION SYSTEMS



Bermite's leadership in ignition systems has been brought about by basic and applied research programs, development of specific systems to meet special customer needs, and production of the largest volume of reliable and qualified igniters for the missile industry.

In addition, Bermite produces safety and arming devices, squibs, ignition materials and unique inert components found in reliable missile systems and JATO units.

Explosive engineers interested in sophisticated projects may submit resumes to the Research and Development director, or at the Washington area office, 914 North Chambliss Street, Alexandria, Virginia.

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Bermite Powder Company

22116 West Soledad Canyon Road, Saugus, California

—reviews

PERARYLATED SILANES: A CLASS OF STABLE ORGANIC MOLECULE, L. Spialter and C. W. Harris, WADC. Order PB 151860 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 22 pp. $.75.

Air Force chemists predict production of many new materials from perarylated silanes, a new organic system notable for its size, versatility, radiation and heat stability. But, the researchers say, much developmental work remains to be done.

The perarylated silanes comprise a class of molecules which contains hundreds of thousands of members constructed by combining silicon atoms and aromatic groups into various molecular arrangements. Some types have shown unusually high resistance to radiation, oxidation and high temperature (to 600C).

Their versatility may lead to use in lubricants, hydraulic fluids, insulators or dielectric materials, and radiation-detection materials. The possible production of new stable elastomers and plastics from polysilarylene polymers is promising. Chemical derivatives of these types may lead to new adhesives and synthetic fibers.

Air Force chemists call for stepped-up developmental efforts in such areas as the preparation of new molecular species, polymers in particular. New chemical derivatives and special equipment are needed to iron out shortcomings of molecules now available.

SUPERSONIC WIND-TUNNEL TESTS OF RING-WING CONFIGURATIONS, L. H. Schindel, M.I.T. for WADC, Order PB 151754 from OTS, U.S. Dept. of Commerce, Washington 25, D.C. 108 pp. $2.50.

In this study, supersonic wind tunnel measurements were made of aerodynamic forces and moments on ring-wing configurations. This has been considered a natural shape for a tube launched missile.

The main result was an indication that the combination of linearized and slender body theories is not adequate to design a ring-wing vehicle with zero wave drag.

Other tests provided data on tandem ring-wings and on the lifting effectiveness of support struts. In addition, some experimental results were compiled on the area ratio required to start supersonic flow in the annular region between wing and body.

Although no new contributions are made to ring-wing theory, the illustrated report does contain an extensive review of its state of the art.

THE OPTICAL INDUSTRY DIRECTORY, The Optical Publishing Company, Lennox, Mass. 254 pp. $5.

The 1959 issue of the Directory lists some 400 items pertinent to the industry —instruments, components, raw materials, and services.

Also listed is information concerning 1200 American company sources capable of furnishing these items and a complete catalog of all corrected lenses, both domestic and foreign.

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Built-in reliability inspires devotion everywhere for the new **Mincom Model CV-100 Video Band Magnetic Tape Recorder/Reproducer.** Only 12 moving parts, four simple adjustments. No mechanical brakes. Seven 1-megacycle video channels on a single half-inch tape. Tape speed of 120 ips, coupled with specialized circuitry, produces a reliable frequency response from 400 cycles to 1.0 megacycle (each track). Signal-to-noise ratio: 30 db, peak signal to rms noise. All plug-in assemblies, carefree maintenance. Interested? Write Mincom today for specifications.

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THE AW HAYDON COMPANY
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contracts

AIR FORCE

Boeing Airplane Company was chosen to build the *Dyna-Soar* manned space glider and **The Martin Company** to produce rocket boosters to power the vehicle.

No estimate of the eventual cost of *Dyna-Soar* was announced, but the Air Force said it had $53,000,000 available for the project in the current fiscal year ending next June 30.

The dual selection ended a lengthy contest between contractor teams headed by Boeing and Martin. (See story on page 49.)

Allison Division of General Motors has received a contract for the design, fabrication and performance testing of an earth satellite powerplant. Amount not disclosed.

$2,000,068—**Collins Radio Co.**, Dallas, Texas, for providing a microwave communication system.

$709,930—**ACF Industries, Inc.**, Riverdale, Md., for a KC-135A and MB-26 flight simulator, spare parts, test equipment, special tools, installation services and data.

$624,653—**United States Steel Corp., Consolidated Western Steel Div.**, Los Angeles, for design and construction of equipment for an inertia measuring platform.

$217,301—**Sylvania Electric Products, Inc.**, N.Y., for various electron tubes. (Two contracts.)

$203,340—**Tung-Sol Electric, Inc.**, Newark, N.J., for various electron tubes. (Three contracts.)

$190,100—Cornell University, Ithaca, N.Y., for continued research in "Theory and Application of Precision X-Ray Spectroscopy in the Study of Solids."

$181,601—**Boeing Airplane Co.**, Pilotless Aircraft Div., Seattle, for reproducible copy and negatives applicable to the *IM-99A* missile. (Three contracts.)

$104,426—**Collins Radio Co.**, Dallas, for contractual maintenance and operation of microwave system.

$81,745—**Radio Corp. of America**, Harrison, N.J., for electron tubes. (Two contracts.)

$71,523—**Westinghouse Electric Corp.**, Elmira, N.Y., for electron tubes.

$40,921—**Bruno-New York Industries Corp.**, N.Y., for simulator-antenna position, maintenance handbook data and engineering data.

$40,658—**Raytheon Manufacturing Co.**, Waltham, Mass., for receivers, three items, various quantities.

$38,600—Wayne State University, Detroit, Mich., for research.

$28,309—**Southwest Research Institute**, San Antonio, Tex., for continuation of research and reports on radiation-induced free radicals in chemical and biological systems.

$27,937—**Allen B. Du Mont Laboratories, Inc.**, Clifton, N.J., for electron tubes.

$27,422—**Radiant Manufacturing Corp.**, Morton Grove, Ill., for 930 portable screen projection BM-10.

$27,000—**Bomarc Laboratories, Inc.**, Beverly, Mass., for various electron tubes.

NASA

$207,000—**Electronic Engineering Company**, Santa Ana, Calif., for radar data handling equipment at Wallops Island, Va., rocket test station.

$100,000—**C.E.I.R., Inc.**, Arlington, Va., for computing services.

$30,735—**Precision Instrument Co.**, San Carlos, Calif., for record reproducing system

MISCELLANEOUS

$300,000—**Polarad Electronics Corp.**, for special microwave receivers with extremely precise calibration. Subcontract from **Western Development Laboratories-Philco Corp.**

NAVY

$3,000,000—**Carrier Corp.**, Syracuse, N.Y., for production of steam-activator absorption cooling equipment for nuclear submarines.

$122,563—**Consolidated Electrodynamics Corp.**, Washington, D.C., for recording oscillograph.

ARMY

$2,430,000—**Samuel N. Zarpas, Inc.**, and **Fullerton Construction Co.** (joint venture) Detroit, Mich., for construction of *Bomarc* facilities at Travis AFB.

$2,200,000—**Ralph M. Parsons Co.**, Los Angeles, for construction of *Titan* test launch facilities at Vandenberg AFB.

$700,000—**The Siegler Corp.**, Hallamore Electronics Div., for special test equipment for the *Sergeant* missile. Subcontract from **Sperry Utah Engineering Laboratory.**

$500,000—**Chrysler Corporation**, Detroit, for modification work on the *Redstone* missile for space application.

$250,000—**Philco Corp.**, Philadelphia, Pa., for *Courier* communication satellite.

$235,000—**North American Aviation, Inc., Rocketdyne Div.**, Canoga Park, Calif., for design and development of a motor.

$219,264—**Raytheon Corporation**, Andover, Mass., for repair parts for the *Hawk* missile system.

$160,834—**Western Electric Co.**, N.Y., for *Nike* spare parts and components.

$140,640—**Askania-Werke**, Bethesda, Md., for cinetheodolites with tool kits and aided tracking drive systems.

$133,778—**J. W. Fecker, Div. of American Optical Co.**, Pittsburgh, Pa., for design and construction of 16 lens internal leveling system and target focusing for cinetheodolites.

$104,280—**Resdel Engineering Corp.**, Pasadena, Calif., for receivers, oscillators, schematics.

$89,130—**Emerson Electric Manufacturing Company**, St. Louis, for *Honest John* M2A1 pedestal assemblies with electrical installation and batteries.

$49,490—**Hughes Aircraft Co.**, Culver City, Calif., for study of radiation on missile components.

$48,266—**Radiation Electronics Corp.**, Skokie, Ill., for thermal imaging systems.

$46,467—**Surprenant Manufacturing Co.**, Clinton, Mass., for research and development design, in development and fabrication of prototypes of improved multiconductor cable and connectors.

$29,775—**Bourns, Inc.**, Riverside, Calif., for pressure transducers.

Dyna-Soar Puts AF Back In Space

by James Baar

WASHINGTON—The Air Force has soared back into the national space program in a big way with its decision to go ahead with development of the multi-billion dollar *Dyna-Soar* space bomber program.

At the same time, the Air Force dealt a hard blow to the "company team" concept of weapon systems development by personally assuming the prime contractor's role of weapon systems manager for *Dyna-Soar*.

Each of the only two competing primes—**Boeing** and **Martin**—received major parts of the program while members of their respective company teams must now compete independently for contracts to develop major subsystems and components.

Boeing was considered to have received the biggest slice of the program. It will develop the boost-glide vehicle and will be responsible along with the Wright Air Development Division for the integration of vehicle subsystems, the vehicle and the booster, assembly and testing.

Martin will develop the boosters. These are expected to be only slightly modified *Titan* vehicles in the very early stages of the program. Later, the booster may be clusters of four *Titans* providing some 1.2-million pounds of thrust. An alternative—or intermediate step—could be expanding *Titan's* first stage from a 10-foot diameter to 12-feet.

Both **Boeing** and **Martin** received authority to select—subject to Air Force approval—the subcontractors for their share of the program.

However, the Air Force made clear that overall responsibility for management and integration of systems will remain directly in the hands of the Wright Air Development Division.

The Air Force gave no official indication how much cash it was ready to pour into *Dyna-Soar*. It said only that the program has $53 million through FY 1960.

However, the initial development program is expected to cost at least $1 billion—not including the manufacture of any significant number of operational vehicles.

- **Big step forward**—The *Dyna-Soar* program now being launched by the Air Force is a major step beyond the original program that was under consideration as late as last summer.

That program aimed at development of a boost-glide spacecraft that would serve as a laboratory for gathering data that eventually would lead to building maneuverable-recoverable military space ships.

The Air Force decided that developments have already made such a research program unnecessary. It directed that **Boeing** and **Martin** come in with a usable military vehicle, as well as a research craft, instead. It also directed that the vehicle be designed so that it could make use of available boosters, at least in its early stages, rather than call for development of new models.

The *Dyna-Soar I* which will be developed is the result.

Predicted in June

MISSILES AND ROCKETS reported on July 13 that "all signs continue to point to Boeing as winner of the *Dyna-Soar* contract despite Air Force decision to delay making awards." Two weeks earlier, M/R had said Boeing received technical approval from the Air Force and was victor in the design competition.

The *Dyna-Soar* winged space ship with its pilot will be boosted into space at speeds approaching 14,000 miles an hour. By dipping in and out of the edge of the atmosphere, the space ship will be capable of traveling around the earth and landing at a selected site.

It will be capable of conducting reconnaissance, and bombing missions anywhere on earth. It also may be used to intercept enemy satellites and spacecraft.

Dyna-Soar II, which will be developed in the second phase of the program, is expected to be capable of deep space missions. It would have propulsion power to "jump" from orbit to orbit.

The Air Force has announced no schedule for the program. However, the first vehicles probably could be ready for launching within three years. *Dyna-Soars* probably could be operational in five. Much depends on the level of funding.

The first step in the program will be the development of a glider capable of safely bringing a man back to a normal landing after traveling at hypersonic speeds.

Later, unmanned and manned gliders will be launched down the Atlantic Missile Range to explore technical problems of flight at near-orbital speeds. One of the key problems that must be licked is the tremendous heating that the glider's leading edges will undergo in such flights.

The Air Force decision to go ahead with the program, which dates from the Saenger concept first put forth in the 1930's, appeared to be a sharp reversal of the recent Administration trend to take the armed forces out of space.

Only last month the Administration announced the switch of the *Saturn* 1.5-million-pound-thrust clustered booster from ARPA to NASA subject to congressional approval. The switch left the Air Force without a going lunar space program.

The *Dyna-Soar* program changes all that very much.

Dyna-Soar Contracting Teams

PRIME CONTRACTOR

BOEING AIRPLANE CO., SEATTLE,
Flight vehicle and ground support

MARTIN CO., BALTIMORE DIVISION,
System integration

SUBCONTRACTORS

GENERAL ELECTRIC:
Guidance and tracking system, including airborne components

NORTH AMERICAN AVIATION, AUTONETICS DIV.:
Inertial guidance and flight control

CHANCE VOUGHT:
Flight capsule, including escape

SUNDSTRAND AVIATION DIVISION:
Secondary power

RCA:
a) (Second-tier subcontractor not selected.) Air-ground communications subsystem b) (Second-tier subcontractor not selected) Ground communications

CONVAIR OR MARTIN:
Boosters

HERCULES POWDER CO.:
Separation rockets

RAMO-WOOLDRIDGE, RCA:
System studies

GOODYEAR AIRCRAFT CORP.:
Navigation system studies

BELL AIRCRAFT CORP., BUFFALO, N.Y.:
Airframe, airframe subsystems (except hydraulic and electrical), flight control

AMERICAN MACHINE & FOUNDRY CORP.:
Heavy ground handling and launching equipment

BENDIX AVIATION CORP.:
Hydraulic and electrical subsystems; telemetry, and short-range communications systems

GOODYEAR AIRCRAFT CORP.:
Pilot escape system; radar studies

MINNEAPOLIS-HONEYWELL REGULATOR CO.:
Aircraft navigation system; inertial guidance and computer studies

MARTIN CO., DENVER DIVISION:
Boosters

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west coast industry . . .

By FRANK G. McGUIRE

It is doubtful that **Rocketdyne's** E-1 engine will ever fly.

It is a well-designed, powerful engine (400,000 lbs.) using the latest design techniques, but there are a number of factors against the E-1, not the least of which is the current budget-balancing attitude. The E-1 was developed under an Air Force contract to provide answers to many problems of large, high-thrust liquid rocket engines. There is no vehicle for it; there would be a great reluctance to divert funds from other large-engine projects (F-1 and *Saturn*) in support of its further development, and unless public pressure demands otherwise, it will remain an interesting research tool.

The scanty photo caption released with the E-1 held a significant statement: "At the present time, the engine is not scheduled for any specific vehicle." Building a vehicle for the E-1—and doing a good job—would take time, and more money than the government would be willing to spend. It would be necessary to establish a requirement, obtain funding, review proposals, let contracts, and go through the testing and development phases . . . extensive, for such a necessarily-large vehicle. Past history of our rocket programs tells us that constant re-evaluation and re-justification would be required . . . with many people calling for the ax, as has been experienced in our *Saturn* program.

This Administration's record of crash-stretchout-crash programs, dictated by Soviet space achievements, belies any hope that the Rocketdyne engine will ever power a U.S. space vehicle. Nevertheless, it has proven immensely useful in providing data for the F-1, Rocketdyne's 1.5-million-pound-thrust engine for NASA. Nevertheless, with two large, high-thrust projects now underway, we would be very surprised if DOD, Congress, and NASA could all be permanently convinced that the E-1 should be continued into operational status, with all that this entails.

Two innovations at Northrop . . .

may set trends throughout the industry in employe-relations. The company has endeared itself to many by its holiday schedule plan, which calls for an uninterrupted 11-day holiday for employes, from December 23rd to January 4th. The other action calls for a cash award to **Northrop** employes referring eligible engineers to the company for hiring. If the referral is hired in an eligible classification, the employe gets $100.

Spacelabs, Inc., life-support specialists . . .

have established headquarters at Tarzana in the San Fernando Valley. The firm expects to do $200,000 in business during 1960, and $750,000 during 1961. **Spacelabs** will be one of the few companies in the country specializing in equipment designed to support life in space vehicles. Founders were formerly with **Sundstrand-Turbo**.

Hughes Aircraft got unexpected results . . .

by sponsoring a school-children's summer science project with Cal-Tech. The course was intended to provide basic education in determining orbits of astronomical bodies. Instead, the students discovered a 350,000-mile miscalculation in the orbit of one of the minor planets!

Computer Control Co. has cut prices . . .

on many of its electronics components. Ascribed to increased sales and improved manufacturing facilities, the cuts take effect immediately.

Lockheed-Marietta will engineer nuclear rocket . . .

under a negotiated contract with NASA. Seven firms submitted bids, and of the seven, **Lockheed** was chosen for negotiation of a contract calling for basic engineering work on the nuclear rocket system.

Hufford Corp. will build world's largest . . .

machine tool, a 120" diameter spin forge. The largest to date has been a 96" diameter spin forge built for Lockheed. The 120" diameter tool will be built with **Hufford's** own funds, and will be used by the company in its operations.

—when and where—

National Academy of Sciences, Autumn Meeting, Indiana University Memorial Union, Bloomington, Nov. 16-18.

University of Michigan, Fifth Annual Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Nov. 16-19.

American Rocket Society, 14th Annual Meeting, Sheraton-Park Hotel, Washington, D.C., Nov. 16-20.

American Society of Mechanical Engineers, Fifth International Automation Exposition and Congress, New York City, Nov. 16-20.

Instruments Division, Philips Electronics, Fifth Norelco Electron Microscope School, Hotel Victoria, New York City, Nov. 16-20.

National Aviation Trades Association, 20th Annual Convention, Hotel Montelone, New Orleans, Nov. 16-20.

Society of Aircraft Materials and Process Engineers, Eastern Division, Fall Meeting, Sheraton Carlton Hotel, Washington, D.C., Nov. 17.

Institute of the Aeronautical Sciences, National Turbine-Powered Air Transportation Meeting, Fairmont Hotel, San Francisco, Nov. 17-18.

Institute of Radio Engineers, 1959 Northeast Electronics Research and Engineering Meeting, Boston Commonwealth Armory, Boston, Nov. 17-19.

Ninth Aircraft Hydraulics Conference, sponsored by Vickers, Inc., Div. Sperry Rand Corp., Park Shelton Hotel, Detroit, Nov. 18-20.

DECEMBER

AFOSR/Physics Division, Physical Sciences Directorate and NAS/NRC, Conference on Problems Related to Interplanetary Matter, Northwestern University, Evanston, Ill. (Dates still not firm).

Rocket and Missile Symposium, USAF Arnold Engineering Development Center and ARO, Inc., Arnold Air Force Station, Tullahoma, Tenn., Dec. 1-2.

Eastern Joint Computer Conference, Statler Hilton Hotel, Boston, Dec. 1-3.

National Conference on Application of Electrical Insulation, Sheraton-Park and Shoreham Hotels, Washington, D.C., Dec. 6-8.

American Institute of Chemical Engineers, 52nd Annual Meeting, Sheraton-Palace Hotel, San Francisco, Dec. 6-9.

American Management Association, Briefing Session on the Defense Market, Ambassador Hotel, Los Angeles, Dec. 7-9.

First Aerospace Finishing Symposium, sponsored by Southwest Society of Aircraft Materials and Process Engineers, and Dallas-Ft. Worth Branch of American Electroplater's Society, Hotel Texas, Fort Worth, Dec. 8-9.

Institute of Environmental Sciences, New York Metropolitan Chapter, Technical Symposium and Product Exhibition, Henry Hudson Hotel, New York, Dec. 10-11.

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Vital Newcomers of the Space Age

As a sign of the times in which we live, thousands of new companies have been and are being formed throughout this country. They are the results of the Space Age, if you want to call it that, or at any rate of this advanced stage of the world's industrial revolution. They are the products of specialized techniques which have grown to meet specialized needs.

Many of these firms have arisen to answer requirements engendered by fantastically rapid technological advances; some are the results of military requirements, some of space exploration, and some simply of the different way in which we now live.

They deal in items ranging from auxiliary power units through bearings, capacitors, computers, diodes, fluorine, guided missile telemetering, infrared, kilovoltmeters, modulators, nozzles, plasma, radar, shields, test equipment, valves, wind tunnels—to X-ray plotters and yokes—items which run into the thousands.

The men who organized most of these companies are young—frequently under thirty. So are the men and women they hire. The techniques and methods of operation are formulated as they go along. Most of the employees are trained either on the job or in special classes set up by the company, because the fields are so new no experience exists.

Take Company A. It was formed in 1954 with just over $20,000 capital to take on a contract which was about to go by default because no one else could, or wanted to, tackle it. Company A became specialists in the computing field, developed the idea of selling computing service to industry (and government), now do $3 million business a year. Their stock has gone from $6 to $50 a share. They are expanding into a chain which will reach across the nation.

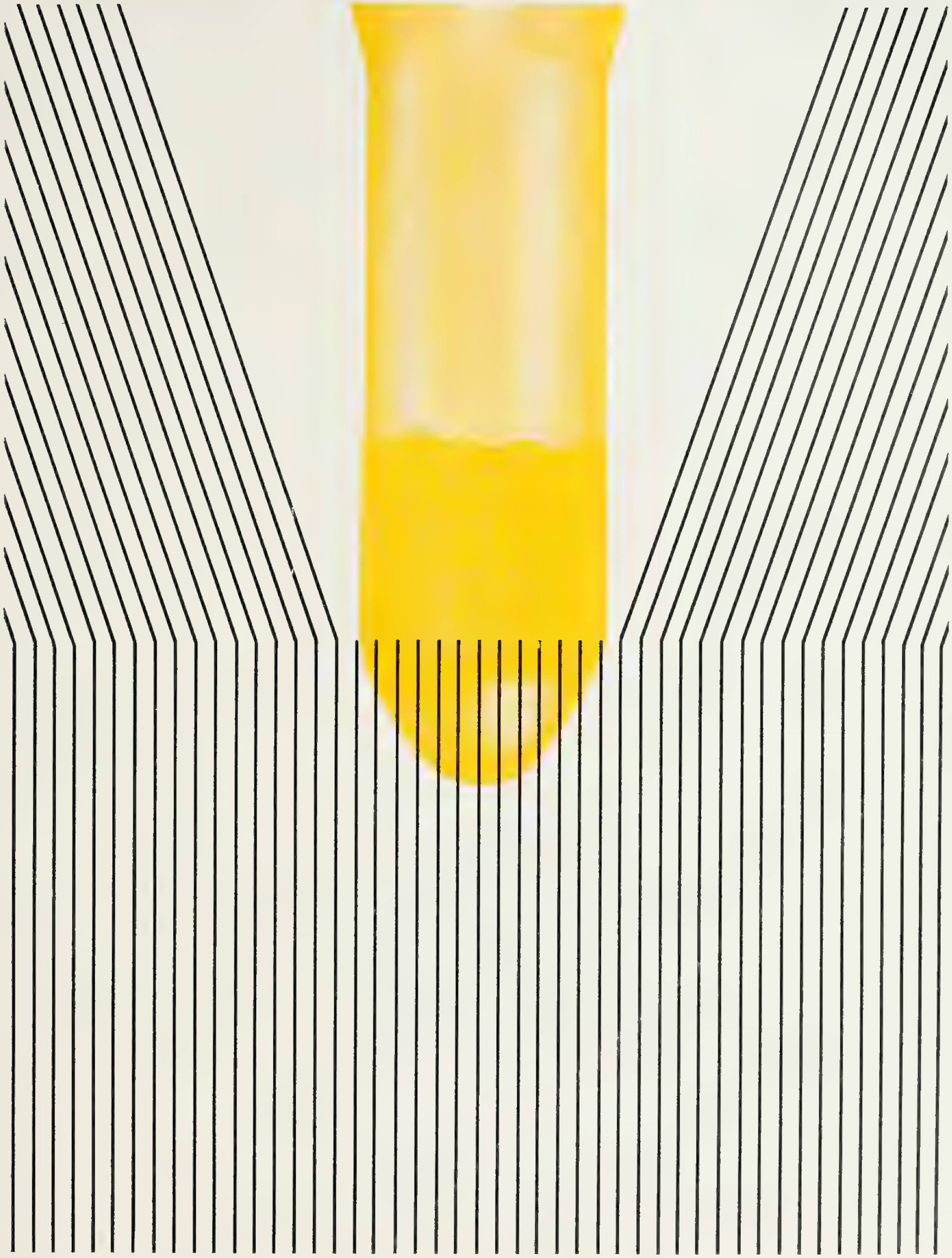
Take Company B, a company formed in 1956 with nine people to fill a need of the age—to build simulators to train ground radar operators. The company now has 248 employees and a backlog of $3.5 million.

Or Company C, now a veteran of nine years of dealing in space electronics, with inevitable by-products for peacetime civilian uses. In just the past year this company's payroll rose from some 780 employees to 1150, while the backlog of orders climbed from $5.4 million to $14.4 million.

These companies and others like them are both in competition with and in support of the business giants which have long ruled our industrial world. As a subcontractor for the big primes, the little man necessarily picks up some of the big company techniques and secrets. But mostly he develops his own. He accumulates his own patents and his proprietary rights. He guards them jealously—to the point of seeking congressional investigations of pirating.

He is a product of the age—or perhaps he has helped produce the age. In either case he is a vitally important newcomer to the world's industrial scene, important for his collective size but more important for the collective skills and ingenuity and the contributions he makes toward solving today's unprecedented demand for products and methods undreamed of just a few years back.

CLARKE NEWLON



Avco cools a nose cone—at 12,000°F. — To bring a space vehicle safely through the 12,000-degree heat of atmospheric re-entry, Avco scientists have developed radically new "space age materials." One of these, a ceramic structure termed Avcoite, made history as it returned this country's first successfully recovered ICBM nose cone. Today, materials research at Avco continues in new and bold directions, ranging from heat-resistant rocket nozzles to lightweight space structures.

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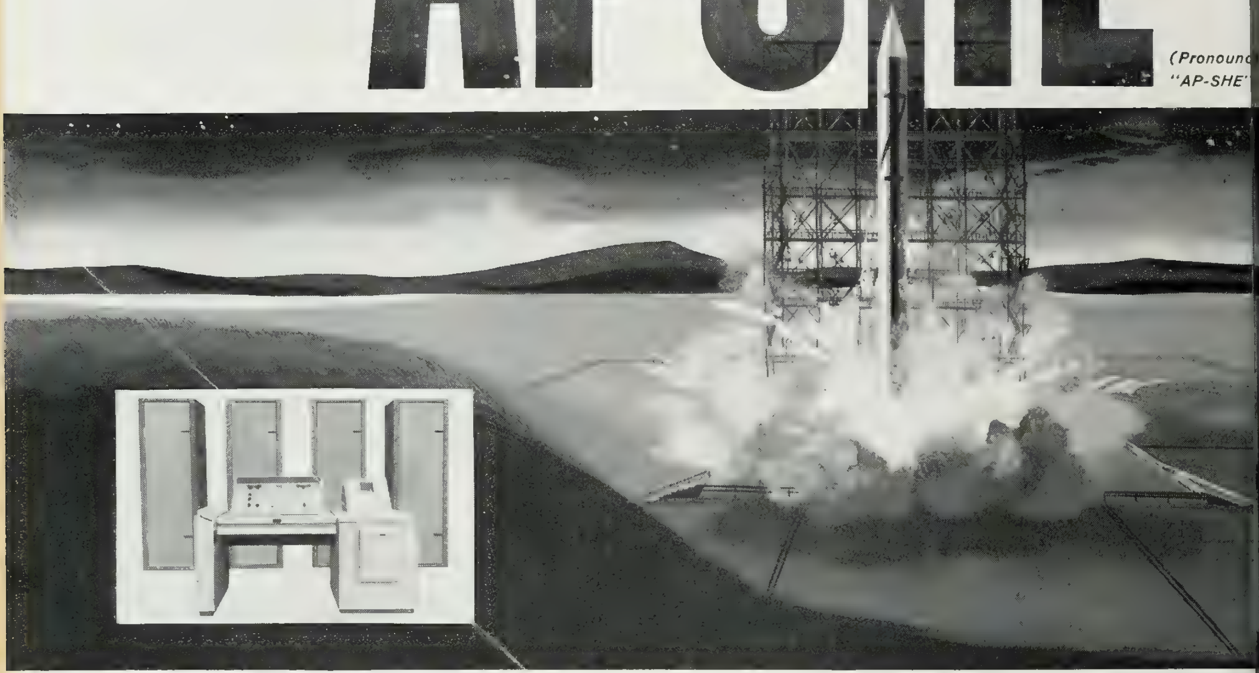

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The system being supplied to Convair for the ATLAS Program includes a console and four rack cabinets providing both analog and discrete test functions with a resulting printed and GO-NO GO indication. As a product of RCA's Missile Electronics and Controls Department, Burlington, Massachusetts, APCHE is one of the latest RCA developments in the field of military weapon readiness equipments.

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"A Mathematical Model of an Air Defense Operation and a Method of Evaluation," a paper by SDC's staff, is available upon request. Please address inquiries to Mr. E. A. Shaw at SDC.

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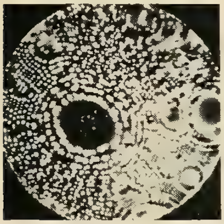
missiles and rockets

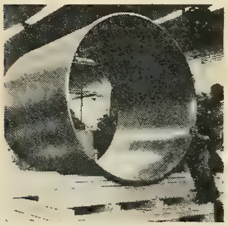
MAGAZINE OF WORLD ASTRONAUTICS

31,000 copies of this issue printed

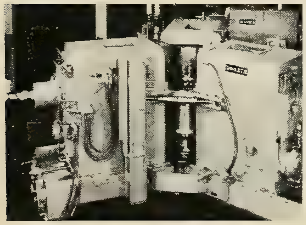
COVER: Braiding stainless steel wire on flexible hose made of du Pont Teflon and fiber glass at the Titeflex Inc. plant in Springfield, Mass. See Story on p. 52.



ATOMS OF tungsten in first photo of single atoms. Taken by field emission microscopy, it is a magnification of 4,300,000 times. A survey of the revolution in materials starts on p. 13.



STEEL CASING made for Aerojet-General by Kaiser Metal Products, using the Hydrospin process. Rockets must be made more reliable and lighter. See story beginning on p. 21.



FLOTURN machine at Pratt & Whitney plant in East Hartford, Conn., turns out seamless cylinders whose freedom from weaknesses affords a major advantage for use in rocket cases.

NOVEMBER 23 HEADLINES

ARS Meets in Washington with New Sense of Urgency
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MISSILE MAKERS SPEAK

Future demands which will have to be met by missile/space materials, as outlined by spokesman for twelve major contractors—General Electric, Aerojet-General, Rocketdyne, Sperry Gyroscope, Ford, Lockheed, Atlantic Research Corp., Chrysler, Bell, Norair, Republic Aviation and Army Ordnance Missile Command—starting on page **19**

MISSILE SUPPLIERS SPEAK

Spokesmen for 47 other companies outline the state of technology in their areas of specialization, starting on page **38**

EXPLOSIVE FORMING

Lead article on this remarkable technique by Dr. John S. Rinehart, of the Colorado School of Mines. Other stories from du Pont and American Potash **72**

THE MISSILE WEEK

U.S. Reg. Pdg.

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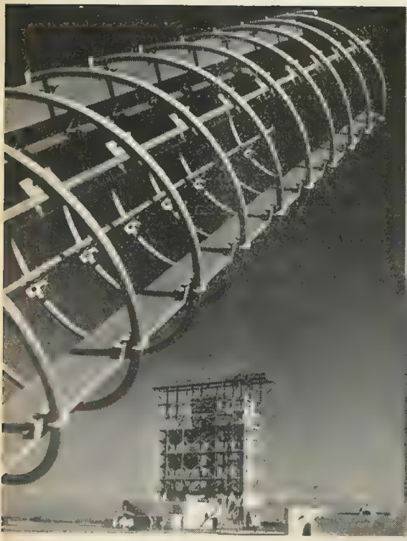
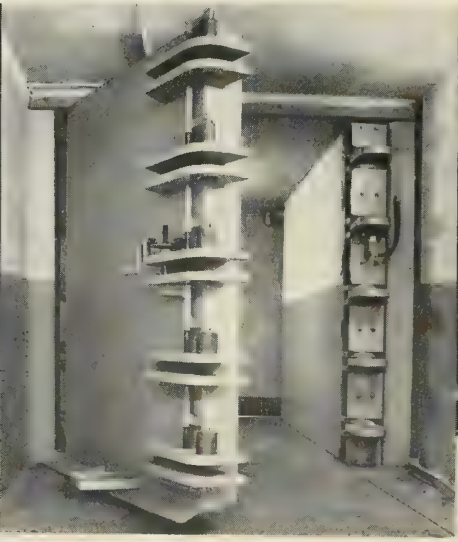
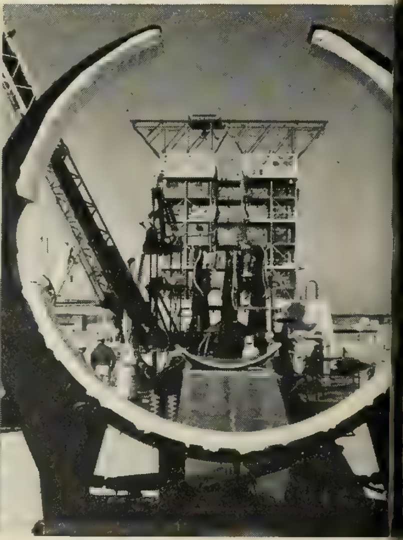
About the earthly side of Canaveral—Only recently, it spawned little more than snakes and other crawling creatures. Today, high flying birds are poised there, and because they can't jump off from sand, most of the Canaveral manpower and materials go into ground support equipment. And virtually all the steel material required can be purchased from one source—United States Steel. Whether we're talking about carbon steel, high-strength low-alloy steel, constructional alloy steel, or stainless steel, steel fence, electrical cable, wire rope or cement,



On this vertical oscillating radar tracking unit, every nut, bolt, and insulator collar is Stainless Steel. To the right, is a Stainless Steel fuel tank, and beyond that rises the U. S. Air Force Thor gantry tower, with a structural steel frame similar to a nine-story building.



The door to the U. S. Air Force Atlas blockhouse weighs 24 tons. It is solid manganese steel about eight inches thick. At X minus 15, the door automatically locks and it is blast-proof and vapor-proof.



The mobile transporter for the Thor is strong but light on its wheels because it was designed with weight-saving high-strength steels. Slanting to the left is the steel umbilical tower which carries Stainless Steel fuel lines and control lines.

United States Steel maintains the technical services to provide the proper assistance to cope with any problem on these materials for ground support. When a ground support program is still on the drawing board, consult

United States Steel

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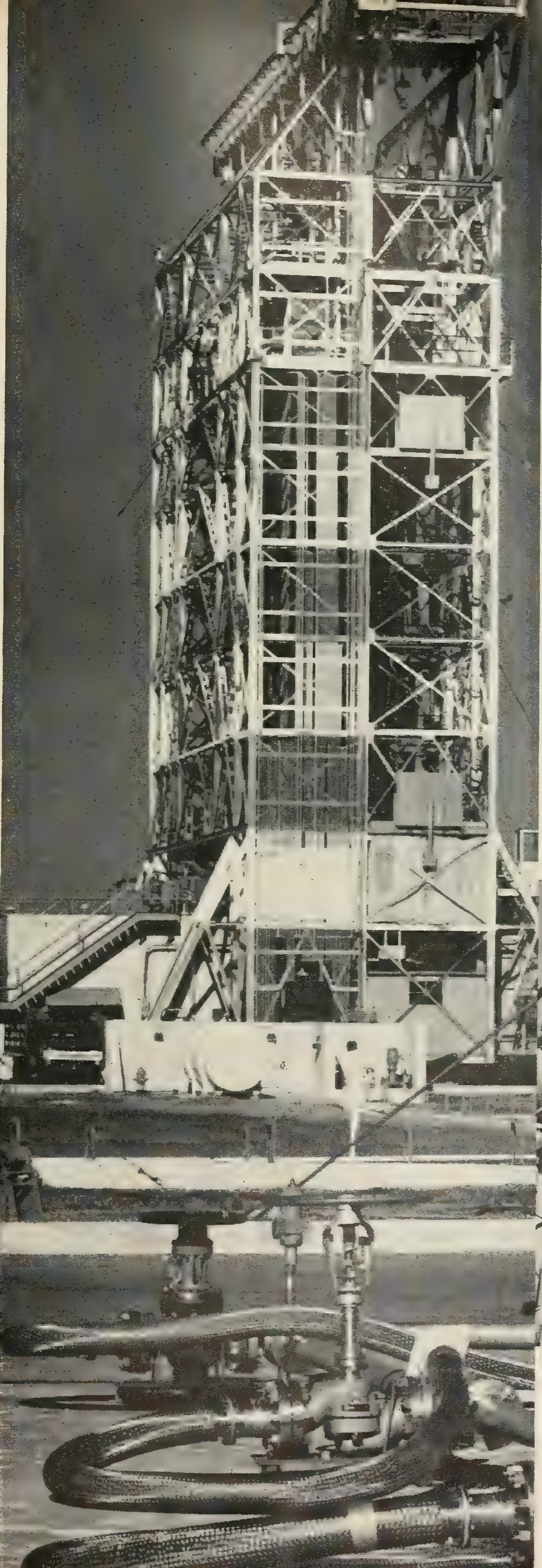

hese pressure vessels for the U. S. Air Force Bomarc A system e seamless steel cylinders about 20 inches in diameter and 26½ et long. The cylinder walls are slightly more than an inch-and-a-alf thick and will contain gas at pressure up to 4500 psi.

tainless Steel pipes and Stainless Steel flexible tubing carry the el for the Thor complex. Fuel lines must be almost surgically clean prevent explosions and assure proper flow. Inspectors check the es with everything from microscopes to ultraviolet lamps. ▶

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Washington Countdown

IN THE PENTAGON

The coming Missile Gap . . .

may be preceded by a Bomber Gap as a result of the tight defense budget being planned for FY 1961. The Air Force may have to cut some SAC bomber wings in order to make ends meet.

• • •

Trouble in NATO . . .

also is expected to result from other proposed cuts—these in foreign aid. The cuts would delay the flow of U.S. Army tactical missiles to NATO troops.

• • •

The number of *Polaris* subs . . .

in the new budget may hang on whether the Navy insists on construction of a second nuclear-powered carrier. With the carrier, the Navy would get only three of the missile-launching subs. Without the carrier, the Navy might get five.

• • •

The next generation ICBM . . .

after *Minuteman* may be *Midgetman*—a far smaller, lighter, easier-to-handle bird. *Midgetmen* might also be used as an anti-missile missile.

• • •

One million pounds . . .

of thrust appears to be the Air Force goal in calling for industry to come up with designs for a huge new solid rocket motor. Such a booster would have a number of military applications. Powering *Dyna-Soars,* for instance.

• • •

A second giant test stand . . .

planned for Edwards AFB may be built to accommodate rocket engines exceeding 1.5-million pounds of thrust. Air Force and NASA funds will be used. One stand for 1.5-million-pound-thrust boosters already is under construction at the aero-space base.

• • •

Special 'mole pay' . . .

for "molemen" manning hardened ICBM bases is under consideration by the Air Force. The extra money for servicemen spending a specified number of hours underground each month would be comparable to flight pay.

ON CAPITOL HILL

Space patent law . . .

will get a going-over early next month before the House Space Patent Subcommittee. Hearings on whether the patent provisions of the National Space Act should be revised are scheduled to open Nov. 30.

• • •

Tithe for science . . .

legislation is expected to receive new attention when Congress opens for business in January. The proposal would call for adding 10% for basic research to all military and space R&D appropriations.

AT NASA

Sodium vapor tests . . .

being conducted with sounding rockets at Wallops Island will provide information for both Project *Mercury* and *Dyna-Soar*. The tests are yielding data on wind velocities between 50 and 150 miles above the earth.

• • •

The *Mercury* Astronauts . . .

are undergoing heat chamber tests in their space suits at the **Air Crew Equipment Co.** in Philadelphia. Temperatures exceed 150 degrees.

AROUND TOWN

Some of the reports . . .

being passed around the nation's capital:

. . . The Air Force is considering construction of ICBM bases on sparsely inhabited Pacific islands.

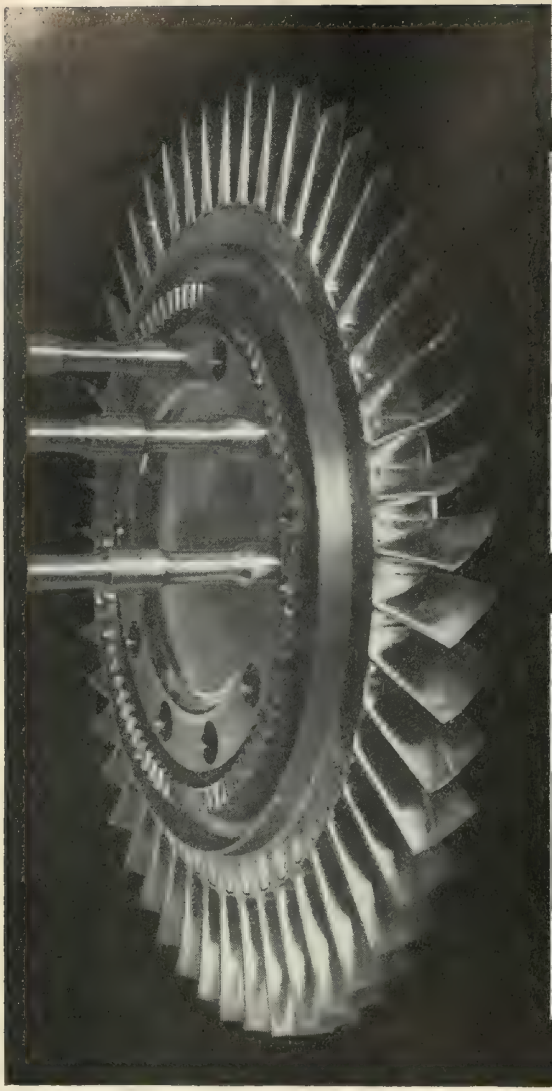
. . . The Defense Department is having a rough time finding a top man to head ARPA for only the Administration's last year.

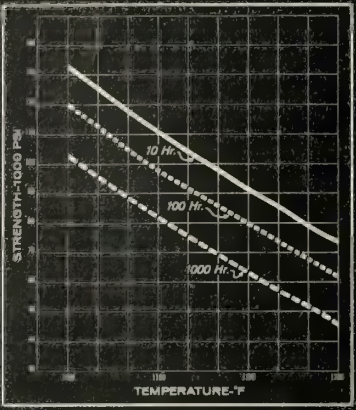
. . . The Senate Space Committee will hold its fire on the Administration space program until early next year.

• • •

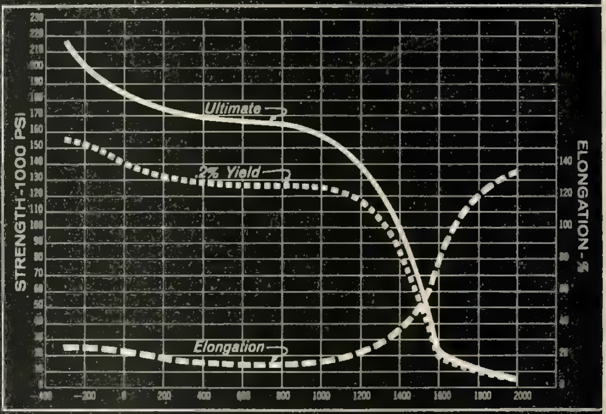
Five Soviet scientists . . .

attending the American Rocket Society's annual meeting in Washington received only nine-day visas from the State Department because that was all the time they requested. If they had asked for a longer stay for more extensive travel, it would have been given consideration.





W-545 STRESS RUPTURE STRENGTH vs. TEMPERATURE



W-545 TENSILE PROPERTIES vs. TEMPERATURE

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Twenty percent more strength at 1200°F from this turbine disc gave added dependability for a Westinghouse customer using W-545. This new high-temperature alloy will withstand higher stress levels than similar alloys at the same operating temperatures . . . or it will withstand equivalent stress characteristics at 100°F higher operating temperatures.

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Industry Countdown

MANUFACTURING

Less work for industry???

The fund-pinched Army reportedly is circulating a memo directing that as much ordnance development and production as possible be retained in-house to keep its arsenals busy. Several prime missile contractors are said to be worried that follow-on contracts may be diverted to arsenals—particularly in the propulsion field. Cut-down on private contracting would be gradual, and it would be felt next year. The memo, according to industry sources, was put into circulation one month ago. However, the Army denies such a memo exists.

• • •

AF will spend $6 million . . .

on developing process for producing very high temperature graphite for leading edges of re-entry vehicles and for nuclear reactor applications. One of the leading contenders for a share of the program is **Raytheon Co.'s** new "pyrographite"—manufactured from deposits of carbonaceous vapor at temperatures above 3632°F.

• • •

Huge plastic "bubbles" . . .

are being proposed as means of solving problems of assembling either platforms in space or constructing lunar bases. The bubbles would have self-contained atmospheres . . . removing the requirement for workers to wear special space suits.

• • •

'Profit for performance' . . .

The largest Air Force cost-plus-incentive-fee contract ever awarded—$100 million—has gone to **General Electric's** Missile and Space Vehicle Division for *Atlas* and *Thor* re-entry vehicles. The contract is a new type and may signal a break in DOD's tough position on incentives.

PROPULSION

Only three more . . .

of **Grand Central Rocket Co.'s** LKS 54,000 pound thrust *Mercury* escape motors remain in development phase before they enter qualification (99.9% reliability). Roughest chore is in aligning the three nozzles to vehicle where the tolerance is 1/186,000 of a millimeter.

• • •

Largest mixing machine . . .

in the solid propellant industry also is claimed by GCR. The 350-gallon container can mix 5000 pounds in one batch—only two mixes are needed to fill the 7000-pound *Nike-Zeus* sustainer.

• • •

For field loading . . .

of solid boosters, **Rocketdyne** has come up with a "QuickMix" process where dry and liquid ingredients are blended in a liquid carrier at high speeds, with no appreciable heat build up. Mobile pilot plant with 500 pounds-per-hour capacity indicates 5000 pound-per-hour plant is feasible.

• • •

Plasma buffs . . .

can't always agree. Two papers at last week's American Rocket Society meeting backed plasma propulsion for inter-orbit lunar missions—but a third paper contended that plasma accelerators aren't well enough understood yet to determine if they are practical for space usage.

ASTRIONICS

First space trajectory . . .

symposium to develop a centralized source of information and reference is being held Dec. 14 and 15 at Orlando. Sponsored by **Radiation Inc.,** ARPA and the American Astronautical Society, the meeting will survey the current state-of-the-art in astromechanics, trajectory computation and optimization, space maneuvers, ascent and re-entry, and fundamental astronautical constants. Proceedings will be printed in book form.

• • •

New TV rocket . . .

is being developed by **Atlantic Research Corp.** Expendable camera would be boosted to 200,000 ft. and descend via parachute while transmitting a continuous picture of lower atmosphere and earth's surface over standard meteorological radiosonde frequencies down to 70,000 ft. System reportedly would be cheaper than one requiring a motion picture camera and recovery.

WE HEAR THAT—

Rocket jump belt . . .

for infantrymen may be bought soon by the Army from **Thiokol** . . . Anti-ICBM guidance techniques evaluation is underway at **Boeing Aircraft** . . . Series of minor mishaps have been plaguing **The Martin Co.** *Titan* program—delaying current test shots at Cape Canaveral . . . Britain's *Black Knight* re-entry vehicle (powered by the **Bristol Siddeley** Gamma engine) has had five successful flights at Woomera . . . also "Down Under" the **de Havilland Propellers Ltd.** *Blue Streak* is nearing flight test.

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Materials: a New Era Begins

All elements, all compounds will be used to meet stern demands of space and nuclear technology; hundreds of millions spent on materials research

by Jay Holmes

WASHINGTON—The materials with which men work characterize the epochs of history. In describing ancient times, we speak of the Stone Age, followed by the Bronze Age and the Iron Age. Ours has been the Age of Steel. But this age is coming to its end.

Spurred by the demands of space flight and nuclear technology, man is entering an era in which he will use not just a few but all the elements in the periodic table. And with the aid of chemistry, he will use not just the compounds found in minerals but every possible combination and permutation of the elements.

A century from now, historians assessing the accomplishments of man's first 100 years of exploring space may well decide that the most important was the introduction of new materials on earth—liberating him from restriction to a few metals, wood and a dozen kinds of stone.

Already, metallurgists are working with such hitherto unlikely elements as molybdenum, niobium, tantalum and the rare earths. New alloys announced recently include a steel including yttrium, aluminum with added lithium, nickel mixed with a dozen different elements. And in chemistry, there seems to be no limit at all to the number of possibilities.

Why introduce new materials? Because those in existence won't do the job in space. Missile and space vehicle designers today are in a situation like that of a small boy at a party where unlimited amounts of ice cream, cake, candy and soda pop are served. He can ingest the goodies but his stomach cannot digest them.

Similarly, the designer often must swallow more of a space mission than the materials at hand can digest. In propulsion and space flight, the materials must contend with extremely high temperatures, pressures and vacuums. Particle erosion, radiation and micrometeorites add to the difficulties. And, to top it all, the entire system must have minimum weight.

To develop the materials, government, industry, universities and independent laboratories are spending hundreds of millions of dollars annually. But despite this grand scale, not enough is being done. The programs are not touching all bases. The reason for this is simple. No one agency is responsible for a comprehensive program of materials research for space.

• **Exponential curve**—But an even more pervasive problem is communication. The sheer volume of research is staggering. If a design engineer were to read all the reports on materials research even in one narrow area, he would have no time to design. The amount of research in the United States since World War II is greater than all that was performed between 1776 and that time. And the curve is exponential. It may take only a few years before this quantity is doubled again.

How is materials research information distributed? In many ways. Scientists doing similar work often communicate privately. Papers are given at professional meetings and published in journals. Periodically, such organizations as Wright Air Development Center, Air Research and Development Command, Office of Naval Research and Stanford Research Institute conduct special symposia on materials. Nevertheless, only part of the information filters through to the engineers who must use it.

But even if they received all the necessary facts, the engineers probably would be unable to absorb them. For the problem is not simply one of adding a few new items to an existing technology, as for example in the case of new information about steel. In this case, the engineer already has learned the basic information in college and in his previous experience.

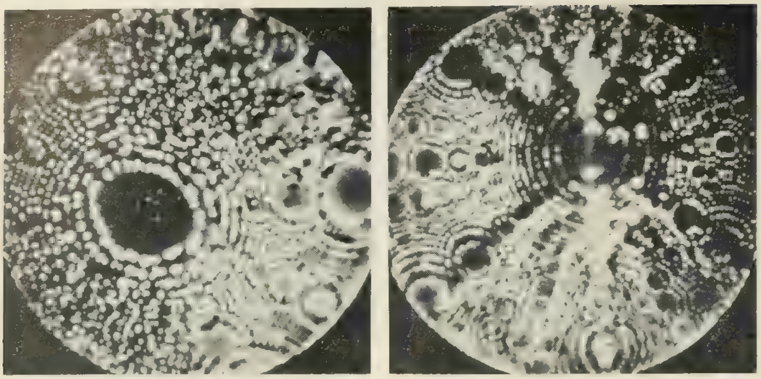
The new materials create entirely new technologies. There is no underlying experience. The engineer did not learn about their properties in college. Even as recently as five years ago, many materials in wide use today were laboratory curiosities or had never been made.

• **Clearing-house activities**—One current approach to solving the problem is by centralizing information, if possible on punched-card files, and establishing materials information centers. The Army is establishing a plastics center at Picatinny Arsenal, N.J. The Solid State Directorate of the Air Force Office of Scientific Research is circulating a proposal for a central national materials research laboratory. The National Bureau of Standards expects to increase its clearing-house materials information activities.

In an effort to gauge the amount of Space Age materials research, MISSILES AND ROCKETS undertook a survey of projects sponsored by government agencies. It soon became apparent that even so modest an objective is extremely difficult to attain. For only the Air Force centralizes its research and development. In the Army and Navy, it is attached to each technical service and bureau. Furthermore, all services have separate research activities attached to every major weapons system.

In the National Aeronautics and Space Administration, materials research is centralized to some extent. But separate activities again are carried out in connection with major programs. The Bureau of Standards has materials research in progress in all of its sections. The Atomic Energy Commission was not included in the survey because, although much of its materials research will be of value in the space program, the activity obviously is aimed in another direction.

John Garrett, materials specialist in the Department of Defense, estimates that the military is spending several



TUNGSTEN ATOMS, enlarged 4,300,000 times at left and 2,750,000 times on right, photographed in 1956 by E. W. Muller of Penn State under Air Force research contract, gave man his first look at individual atoms.

hundred millions this year on materials research, most of it aimed at developing missile and space materials. The research ranges from the most fundamental studies of the nature of matter to extremely practical programs for sheet-rolling metals such as molybdenum and titanium.

• **More scientists needed**—In a program, Project *Pontus,* the DOD's Advanced Research Projects Agency is seeking to get at the root of the matter by increasing the supply of scientists capable of materials research. ARPA expects to obligate about $15 million this year to establish materials research centers in three to five universities. Dr. John Kincaid, ARPA scientist in charge of the project, said he expected to complete a preliminary screening this month of about 20 universities that have expressed interest in taking part.

The centers will work in such areas as high-temperature physical chemistry, organic chemistry, solid state physics, metallurgy, ceramics and engineering. The aim is to uncover new information in these areas, while training graduate students and increasing the supply of materials specialists with advanced degrees. Thus some of the government money may go for stipends, he added.

The three services are spending about $70 million on materials research this year, most of it much closer to the end product. However, this sum also includes $12 million for fundamental studies, about $4 million for each service. Of the rest, the Air Force is spending almost $28 million, the Navy $23½ million and the Army almost $18 million.

• **Space room**—A large item not included here is a multi-million-dollar Navy Bureau of Aeronautics program for sheet-rolling titanium, molybdenum and other new metals. BuAer is sponsoring construction of an 80'x40'x20' argon-filled "space room" at the **Universal Cyclops Steel Co.** plant in Bridgeville, Pa., with a rolling mill, forge and facilities for welding and brazing reactive metals. The room is expected to be completed by the end of the year.

Other programs are the research associated with each weapon system and an ARPA applied materials research program.

• **NASA research**—The space agency is spending something over $5½ million on materials research, about 55% on high-temperature materials, 10% on high-strength materials, 20% on space environment effects and the remainder on fundamental studies. Most of NASA's research is in-house.

In addition, the space agency has a sizeable program in connection with its nuclear propulsion program, Project *Rover,* which it sponsors jointly with the AEC.

The Bureau of Standards devotes between 25% and 30% of its $36 million budget to fundamental materials research. The Bureau is considering establishment of a center for information on preparation of pure crystals, in addition to some increase in its materials research activity. Dr. Irl C. Schoonover, associate director for planning, says all basic research in materials is of value in some phase of the space program.

Schoonover said the nation needs more centralization of materials information than exists now. One solution, he said, might be a central clearing house of materials information. He said such an institution would have to be staffed by research specialists but it should not itself attempt to engage in research. Instead, he said, the level of activity at existing institutions should be increased.

• **Central laboratory**—Charles Yost, director of solid state sciences in the Air Force Office of Scientific Research, is circulating a proposal for establishing a central national laboratory for basic studies in the properties of crystals and preparation of specimens for study. Such a laboratory would be a leader in the field, he said.

The MISSILES AND ROCKETS survey disclosed that many agencies are hard at work developing and learning to work with high-temperature metals, coatings, ceramics and cermets. The same is true of high strength structural metals and plastics. Vacuum research is getting increased attention—so that materials are available for use in space.

But many scientists feel that the level of effort is too low. Last summer, the Materials Advisory Board, of the National Academy of Sciences conducted an ad hoc study of materials research. Although its recommendations have not yet been published, it is known that the consensus is that the level is too low, chiefly because there is no comprehensive program of developing materials for space.

For example, the scientists who took part felt more activity is needed in such areas as vacuum research, surface effects, very low density structural materials and temperature control by emissivity and absorption.

Like many other aspects of the space program, it appears that materials research needs someone in charge.

GE Reveals Process For Making Diamonds

SCHENECTADY, N.Y.—The process for producing man-made diamonds—covered until recently by U.S. Government secrecy order—has been revealed here by **General Electric** Research Laboratory scientists.

The essential breakthrough involved in transforming carbon into diamonds was the use of a molten metal catalyst, which acted as a thin film between the carbon and the growing diamond crystal. The molten film and the development of new superpressure and high-temperature apparatus made possible the long-sought transformation.

Without the catalytic action, it is estimated that pressures of 3,000,000 psi and temperatures of over 7000°F would be necessary to transform the carbon into diamond. No equipment presently exists that could produce such a combination of sustained pressure and temperature.

The catalyst metal can be chromium, manganese, iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium, platinum or tantalum.

in propulsion and re-entry . . .

Temperature Barrier Slows Progress

Refractories need oxidation-resistant coatings; ceramics too porous or brittle; cermets unreliable; Air Force bets $6 million on graphite.

John F. Judge

WASHINGTON—High temperature constitutes a phase of the current space effort on which all lines of progress converge—and slow to a crawl.

The immense and complex problems caused by the temperatures encountered in every mission through and beyond the earth's atmosphere are the most unyielding obstacles to the advancement of our space program.

Every solid known to man has a definite limiting temperature, beyond which it is either a liquid or a gas. But some problems become acute long before this limit is reached. There are phase changes, oxidation and other conditions which affect the operation of the material.

Thus the broadest significant term applicable in this field is resistance—resistance to high temperatures, to thermal shock, to thermal conductivity, to erosion, corrosion and oxidation.

Finding the material is only part of the picture. We must learn to work it—to forge, sinter, cast or machine it into usable shape. We find ourselves in a situation similar to the legend of the inventor of the universal solvent—how was he going to get his product to market?

But there is no one high-temperature problem. Each application is different. The temperature ranges themselves are created by man. They are determined by passage in and out of the atmosphere and the conditions in the reaction chamber of the vehicle itself.

In the last four years the search has broadened to include an extremely large number of materials. The substances explored range from the familar to the unexpected.

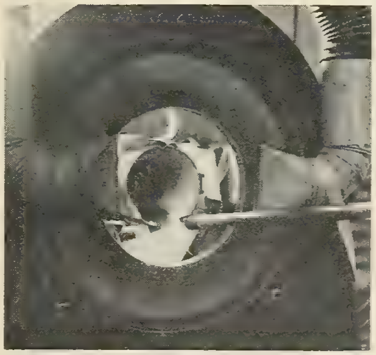
- **Refractory metals**—The classic area of refractory metals is probably the largest and most comprehensive source of high-temperature substances.

Roughly taken as all those metals whose melting point either equals or exceeds that of chromium, the refractories have an inherent deficiency—their low oxidation resistance. This difficulty is overcome to some extent through alloying, but the area thus far explored is a minute part of an unknown whole.

This disadvantage of oxidation points up the fact that refractory metals are characterized by good retention of strength at high temperatures rather than high strength per se. Robert I. Jaffee of the **Battelle Memorial Institute** says that, as a first approximation, the potentialities for high-temperature strength increase as the melting point increases.

The metals that seem to be of the highest interest are in groups V-A and VI-A of the Periodic Table. For an extended discussion of the advantages and shortcomings of each of these metals—such as the low modulus of niobium and its high rate of oxygen diffusion, the high density of tungsten and its high ductile-to-brittle transition and the high thermal conductivity of molybdenum and tungsten and their low expansion coefficients, see M/R Aug. 31, 1959, pages 13-15.

Some of the companies that specialize in refractories are: **Astrometals, Cleveland Pneumatic Industries, Wah Chang, Titanium Metals Corp. of America, Firth Sterling Inc., Beryllium Corp., Brush Beryllium Corp., Nuclear Metals, Union Carbide Metals, Fansteel Metallurgical, Sylvania, Nuclear Corp.,** and **Alloyd.**



CERAMIC COATING applied to inside of combustion chamber and exit cone for Thiokol pre-packaged liquid engine.

The recent applications of refractory metals are in two major categories. There are the sheet applications for leading edges of hypersonic vehicles and the large, heavy forgings of the more refractory metals such as molybdenum, tantalum, and tungsten.

The major problems in the forgings are in obtaining sufficient ductility to withstand fabrication and the more severe thermal shock conditions of actual use. The stress problems are much less severe in leading edge applications.

- **Surface films**—Besides alloying, protective coatings can be used to enhance the oxidation resistance of the refractory metals. Many experts feel that coatings will have to be used regardless of the quality of the alloy.

Experience in the coating of refractories is strongest in the area of molybdenum. **Linde** LM-2 and Chromalloy W-2, based on molybdenum disilicide, are among the best. Ceramic coatings for molybdenum have been developed which are satisfactory for conditions of low stress and high temperature.

Currently, the major means of consolidation of refractory metals are powder metallurgy and arc melting. Electron beam melting is rapidly developing as a third large method.

Refractory metals will advance on many fronts in the near future. Powdered metal alloys will compete with large arc-cast alloys—tantulum-base alloys will develop high-temperature strength—self-healing coatings for oxidation protection will be found—oxidation resistant colombium base alloys will be used for leading edge application without protective coatings, and fabrication methods will improve.

- **Ceramics**—Oddly enough, the

fact that a material has a high melting point is usually of secondary importance. In most cases it is the ability to resist oxidation and thermal shock that counts the most. Ceramics, being characteristically brittle, would seem to be out of the picture. This is not the case. Ceramics are actually competitive with metals at some of the elevated temperatures.

Generally, ceramic coatings are either too porous or brittle. Since they depend on mechanical bonds for adhesion, they usually fail because of poor bonding, lack of ductility and poor matching to the base metal. They are not reliable for systems where the base metal deforms appreciably.

Nevertheless, ceramics offer a great deal in the elevated temperature ranges as a structural insulator, and as protective coatings. In a stiffness, Young's modulus, to weight-ratio comparison, ceramics such as pyroceram and alumina are actually superior to many metals. Characteristics such as this lead many to believe that ceramics cannot be ruled out since further research may well provide breakthroughs.

Firms such as **Minnesota Mining and Manufacturing, Haynes Stellite, General Electric, Kearfott Co., Carborundum Co., Corning Glass, Haveg Industries, Motorola, Norton Co., National Ceramic, Gladding, McBean & Co.,** and many others are hard at work in this area, improving and developing new combinations.

Cermets, a combination of ceramics and metals, have been the object of intensive research in the last decade, especially leading to aircraft applications. However, no cermet of sufficient reliability has yet been found.

The recent production of cermets based on the refractory metals such as molybdenum and tungsten—instead of cobalt and nickel—has increased the likelihood of their use at high temperatures. Cermets' mechanical properties are somewhat better than ceramics'.

Many of the applications for high-temperature materials may not involve oxidizing environments. Then the susceptibility of cermets to oxidation will not be a problem and their high strength can be utilized. For example, a silicon carbide-molybdenum material cermet has a transverse rupture strength of about 42,200 psi at room temperature, but at 1830°F the strength increases to 71,900 psi.

The development of a special flame spraying process by the American Electro Metal Division of Firth Sterling, Inc., has lead to the coating of many base metals and shapes with $MoSi_2$, Cr_2NiB_4, NiAl, and $MoAl_2$. This technique also permits the building up of coatings on an expendable pattern.

- **Oxides**—At elevated temperatures, the excellent chemical stability and corrosion resistance of oxides open another field in materials. As with ceramics, the oxides have the disadvantages of poor resistance to impact failure, low-temperature fracture and poor thermal shock properties.

In single-crystal configurations or dense solids, these materials exhibit their best combination of high-temperature qualities. There is substantial room for improvement through control of composition and structures by better methods and fabrication techniques.

There will be further developments in this direction in the near future. The effect on high temperature applications is bound to be considerable.

- **Plumbago**—The oldest nonoxide super refractory in current use today is graphite. This material has a unique property in the high-temperature field. Its strength increases with increasing temperature until it has almost doubled at about 4300°F.

Not very impressive at room temperature, graphite is stronger than most of the known high-temperature materials, except some of the refractory carbides, above 2900°F. It holds considerable strength as high as 5500°F. The biggest problem with graphite is oxidation, and this has been the object of a great deal of attention.

Minnesota Mining and Manufacturing Co. has developed a siliconized-silicon carbide coating for oxidation protection. **National Research Corp.** deposits molybdenum carbonyl on it followed by a coating of an aluminum-silicon eutectic. After treatment, the graphite winds up with molybdenum disilicide, then an alloy of molybdenum, silicon and aluminum and finally an outer coating of alumina. This protective coating held up for a half hour at 3450°F.

The **Vitro Corp. of America** has developed a technique of depositing either carbide, silicide or metal-alloy coatings on graphite by an electrophoretic process.

The extent to which graphite has been considered in space applications is difficult to estimate. However, the Air Research and Development Command allotted 10% of its present applied research budget of $20 million to R&D on this material and an additional $4 million will be funded in the near future from other sources. If they were given the choice now, Air Force materials officers would use graphite as the leading edge of *Dyna-Soar*.

Another problem is the grade of graphite. The best available has a 25% possible variation in properties. But this must be brought down to at least 5% for space use. Such a grade is possible but it is not commercially produced at present.

- **Ablative materials**—One of the most surprising developments in recent year is the progress made in the use of plastics for high-temperature applications. Focused on the re-entry problem, where temperatures are such that no known material is stable, research revealed that for short-period exposures, certain reinforced plastics were amazingly durable.

The concept of ablation is often defined as the orderly removal of material from a surface in a hyperthermal environment by interaction between the surface and the applied heat and velocity. It is primarily a method of heat absorbtion. While the factors affecting ablation are to a significant degree unknown, the superiority of reinforced plastics has been demonstrated.

Generally, it is agreed that organic plastics are better than inorganic materials and the phenolic resins include the best class of plastics tested to date. But GE scientists feel that it is possible that the superiority of certain phenolics may merely be a reflection of the large amount of development effort that has been expended on them.

The ultimate criterion for selecting materials for high-temperature application is weight loss, but other considerations have proven useful in understanding the mechanics of ablation. Studies at GE of ablated configurations have provided some insight into the operation of the phenomena in terms of steady-state damage, uniformity and freedom from impurities.

An example of the effectiveness of plastics is the *Discoverer* nose cone heat shields. Developed by the **Aviation Products Division** of **B. F. Goodrich**, the shield is composed of several combinations of fabrics impregnated with phenolic type resins.

Machine tape winding under controlled tension and heat forms the shield which is then vulcanized for days at high pressures. Temperature increments are controlled throughout the process, resulting in a fine degree of regulation of the resin content, specific gravity and dimensional stability.

Some of the many firms involved in the development and supply of materials for these purposes include **Taylor Fibre Co., Johns Manville, Union Carbide, Durez Plastics Div.** of **Hooker Chemical, Du Pont, Selas Corp., H. I. Thompson Fibre Glass, Continental Diamond** and **Owens-Corning Fiberglas Corp.**

for space flight . . .

Structural Strength Is Major Hurdle

Flaws in building materials cause many missile failures; poor industry communication often a factor; objectivity, research in materials needed

by Edward W. S. Hull

WASHINGTON—If paper could fly or designs carry payloads it would be the U.S., and not Russia, that is "two to five years ahead" in spaceflight accomplishments.

We have no dearth of detailed systems in the proposal, design and R&D stage. What we lack is the ability to readily and reliably translate dreams into reality—concepts and designs into hardware.

Sooner or later, the problems reduce themselves to structures—materials and how to put them together. Sometimes a big bird fails due to human error, such as the last-minute failure to close a valve or somesuch.

But more often than not, it fails because some piece of hardware did not stand up under the rigors of its intended operational environment. A motor case blows up because of an undetected flaw in the basic material. A missile skin melts under aerodynamic heating. Thermal shock fractures a nozzle insert. Vibration separates the inseparable components of a printed circuit. A missile frame buckles under high acceleration. Radiation changes the chemical structure of a plastic. The dead cold of liquid oxygen embrittles critical aluminum welds.

Take your choice. The causes of missile and space vehicle failure are legion. Sometimes it's a matter of design, but usually it's the inability of a structure to do the job it was intended to do. Structures and materials are rapidly becoming the most critical area of research and development in the entire missile field. This becomes evident when you realize that combustion chemists, propulsion engineers, frame designers, systems engineers and program directors all have stated, financed goals and projects, which in nearly every instance exceed the current capabilities of structures and materials to fulfill the requirements.

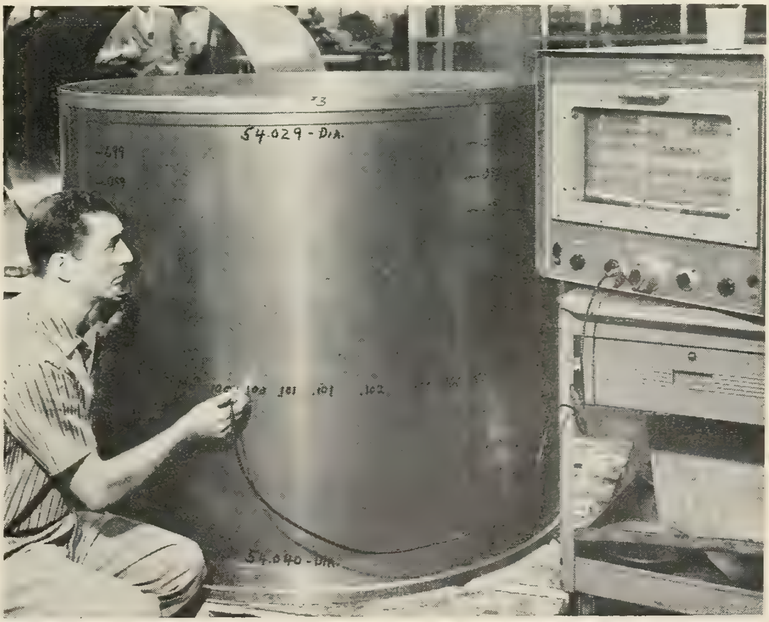
• **Poor communications**—This incapability is due only in part to lack of advancement in the state of technology. Just as often, the blame falls on poor communications within the industry and on the vested-mindedness of people working in one materials field —who refuse to consider the applicability of other materials technologies.

Eight months after unclassified publication of technical papers on notch sensitivity of high-tensile steels, project engineers writing specifications for solid-propellant rocket motor cases in some of the nation's most critical projects had never heard of the phenomenon. They were calling for minimum yield strengths of 220,000 psi in cases where the maximum calculated stress was 165,000 psi *including a 25% safety factor*. When asked why, they replied: "Because it's fashionable!"

Increasingly it is becoming apparent that no single material and no single structural concept is going to be the best answer for all applications of a particular rocket component. Yet pride of authorship, combined with the enthusiasm of a sales pitch and the habits of years, lead one rocket engineer after another to push his technology to the exclusion of all others.

These are customs of the now-dying age of casual technology, which are slow to fade away. Fading they are, however, and the quicker the better. For an increasingly precise and unforgiving requirement in structures and materials is to "let the punishment fit the crime."

• **Varying environments**—The materials of space technology run the gamut from thin mylar films to 500,000 psi music spring steel wire. These



TESTING MOTOR CASE section produced at Kaiser Metal Products Inc., Bristol, Pa. Structures must be strong, light.

must withstand ambient and self-induced environments ranging from 4° to 20,000°K; from zero gravity to hundreds of *g*'s; from the hard vacuum of outer space to the extreme pressures of ballistic re-entry; from zero radiation to the intense "atmosphere" of the radiation belt during a solar flare or the hot innards of a fast reactor; from dry to high humidity.

Lives of missile and space structures range from a few seconds to years. One day, a requirement will call for an extended space probe out to where the sun is a star—years out and years back, enduring sequentially the entire range of conceivable environments. Another specifies the active life of the rocket-powered missile in terms of seconds—birds such as *Hawk, Redeye, Eagle*—but calls for storage lives running into years, often under the inconsiderate conditions of unprotected fields.

In the final analysis each of these requirements boils down to a problem of structures and materials. Design 'em we can. But building 'em is a bird of another color.

The two critical requirements in structures and materials today are:

Informed, imaginative open-mindedness, an ability and willingness to compare requirements with *all* available materials/structures capabilities. Read "Missile Suppliers Speak . . . on Materials." Even applying a discount factor for the inevitable pitchmanship that creeps into such a piece, you'll find capabilities you probably didn't know existed.

A secret in selecting the right materials/structure combination for the job is in comparing operational environmental requirements with the elemental physical capabilities of a materials concept—without initial regard to the traditional applications of that concept. The fact that it's normally used for unbreakable toys doesn't mean it won't be good for re-entry. Look at nylon, for example. It shows off milady's legs. It also will protect a simple steel nose cone from the full rigors of atmospheric re-entry.

Research and more research. One writer in "Missile Makers Speak . . . on Materials" deplores the custom of some materials suppliers of pushing a new material on the market without really knowing either its limitations or its capabilities. He yearns for the day when we'll tailor-make materials, knowing beforehand that they will fulfill the stated requirements.

In a word, we know very little about the basic structure and behavior of materials—about the interfacial characteristics of a metal's granular structure; about the influence of trace elements in metals; about the molecular, chemical and mechanical bonds that hold all kinds of materials together; about why, in elemental terms, one material gives way under a particular environment, while another, which is but little different, rides through without strain.

Such research is just now beginning to be undertaken. Until it begins to produce tangible results we will continue to "muddle through" in a marginal manner. In time, however, operational requirements will demand that we also get efficient. That time is not far off.

One important concept now coming into popularity is the composite structure—utilization of different materials in mixed configurations to do a specific job. This is tailor-making a structure, the next best thing to tailor-making a material.

For example, take the skin of one of tomorrow's manned space vehicles designed to exit and re-enter the earth's atmosphere repeatedly, yet also designed for protracted flight in outer space.

• **Hazards in space**—The erosive effect of the constant bombardment of molecular-sized particles encountered in extended space flight will eventually sputter away the vehicle's surface. Small meteorites going perhaps 100 miles a second have an intense penetrability. Radiation is a menace to both men and instrumentation within the vehicle. Heat balance—absorption vs. emission—is a unique requirement of outer space, dependent on both surface color and texture. Many materials in a vacuum have a vapor pressure such that in due course they will evaporate away. Temperature of re-entry is always a problem.

Thermal shock is yet another problem. So is coefficient of thermal expansion under repeated cyclical heating and cooling. High accelerations are encountered, even assuming the system as designed and built is completely vibration-free. The skin structure may require that a circulation cooling system be incorporated. On top of it all, the structure must both carry heavy loads and maintain its dimensional stability within very close tolerances, particularly when subjected to aerodynamic phenomena during re-entry and flight within the atmosphere.

Obviously, no one existing material designed into a simple structure will fulfill all these requirements and get off the ground. For, above all, it must be light in weight. How then do we design an operational structure? The only existing answer is composites. They would incorporate metals, nonmetallics, plastics and ceramics, and would utilize the advantages of both solid and hollow core construction. One might look something like this:

The basic concept would be a double single-"V" hollow core—three layers of sheet separated by two "V" corrugations. The outer sheet might be inconel (high-temperature strength); outer "V" of copper (strength plus heat sink); middle sheet of stainless steel (moderate temperature strength); inner corrugation of high-temperature plastic laminate; inner skin of plastic laminate. Filling the outer core might be a foamed ceramic heat sink, insulation, meteor barrier; filling the inner core a foamed plastic meteor barrier. Running through either the inner or the outer core might be a circulatory cooling system. Laid on the outer surface of the outer sheet would be a hard high-temperature coating of tungsten carbide. The whole structure might be 1½"-2" thick.

• **Innards stop bullet**—The tungsten carbide's primary job would be wear resistance—against the sputtering action of long-term particle bombardment. It is also a temperature barrier. Inconel is another temperature barrier—also the first in a series of defenses against meteoric penetration. The "V" web of the outer core is also a meteor barrier, presenting a slant surface to the incoming projectile—a principle used to protect the backs of fighter pilots.

Both the foamed plastic and the foamed ceramic offer additional resistance to meteor penetration—just as a man's innards, rather than his bone structure, stop a bullet. The ceramic and the outer metallic structure constitute a high-temperature heat sink. All the bulk acts to stop radiation. For purposes of this discussion we have assumed compatibility of thermal coefficients of expansion and the existence of high-temperature bonding techniques for the plastic.

Whether such a structure will ever be made precisely this way is doubtful, but NASA has determined need for hard outer coating; effectiveness of widely-spaced parallel sheets as impact barriers; need for temperature and radiation protection; etc. It's a far cry from the simple riveted structure of the conventional aircraft, but it's just a hint of what's to come. Note that it employs each of the known basic materials technologies in the manner most suited to its physical characteristics. It's a straightforward, unprejudiced approach, making best use of available technologies. This is the philosophy of doing it now. For the future, as we said, research, research, research.

MISSILE MAKERS SPEAK

In this section, MISSILES AND ROCKETS *is proud to present for the first time in trade publication history a symposium on needs in missile/space materials now and over the next decade.*

To gather information for this special issue, MISSILES AND ROCKETS *went to the men who must know the problem best—those who live with it every day. Prime and propulsion contractors on every major missile and space vehicle system were asked to outline the demands that foreseeable missions will place on the materials of which the structures must be made. The authoritative replies from spokesmen for a dozen major contractors are presented in this section, MISSILE MAKERS SPEAK.*

Stating the needs is but half of the problem, of course. The question is how they will be met. Beginning on page 38 is a second special section, entitled MISSILE SUPPLIERS SPEAK. Here spokesmen for 47 other companies outline the state of technology in their areas of specialization.

Structural Materials Face Tough Demands

by A. A. Watts

CINCINNATI—Operating conditions of solid rocket propulsion systems impose very stringent and widely variant requirements on structural components. Temperatures vary from near-ambient in the combustion chamber walls to about 6000°F in the nozzle. Operating pressures may vary in the range of 500 to 2000 psi.

Gas velocities may reach several times the speed of sound in certain parts of the system. High-temperature corrosion is experienced to different degrees because of the widely variant propellant compositions.

The missile industry imposes three very stringent criteria on solid rocket structural components. These may be defined briefly as (1) maximum reliability, (2) minimum possible weight, and (3) minimum cost. Short-range compromises on weight and cost are possible, but little compromise can be tolerated on reliability. High quality is of paramount importance, and a high degree of precision engineering and design must be associated with very careful control of materials processing and manufacturing operations.

• **Rocket cases**—There are two principal problems in the fabrication of solid rocket motor cases: selection of optimum materials, and selection of optimum manufacturing methods. There are many available materials for fabricating solid cases. These may be classified broadly as: low and medium alloy martensitic steels; hot work martensitic tool steels; martensitic stainless alloys; cold-worked austenitic stainless alloys; precipitation-hardenable stainless alloys; aluminum alloys; titanium alloys; reinforced structural plastics; and metal laminates.

After thorough and exhaustive examination of all of them, it appears that the low-alloy steels are best suited to meet the requirements of the three basic criteria, at the present time.

Of the many available low-alloy steels, compositions based on the AISI-4300 class (or modifications of AISI-4340), appear to have the best combinations of properties from the point of view of strength, ductility, notch sensitivity, workability, weldability, machinability, heat-treatment response and distortion; of available commercial compositions of this type, Tricent Steel (300-M) seems to have the best combination of properties.

• **Design demands**—Steel quality is quite important, and high-quality vacuum-melted steels must be employed to minimize inclusion content, to achieve maximum weldability, and to obtain adequate ductility at design strength levels in excess of 200,000 psi. At lower design strengths, good grades of airmelted steels give adequate performance.

A. A. Watts is Manager — Rocket Materials Development, in the Rocket Engine Section of the General Electric Co.

The basic criteria also establish that a simple manufacturing process is inherently best adapted to solid case requirements. Theoretically, a homogeneous, seamless case represents the ultimate in reliability and weight requirements. Although this design is not possible with the present state of technology, it is recognized that preferred approaches must minimize welding or joining. Cost reductions should be achieved without compromising component performance. Of the many manufacturing methods available, roll-forming (shear-spinning, spin forging, etc.) appears best suited as a simple manufacturing process for the cylindrical portion.

A new hydrospin machine, being built for **General Electric** by **Cincinnati Milling Machine Co.,** is capable of roll-forming cylindrical components up to 75 inches diameter by 100 inches long. This will be available early in 1960 for manufacturing solid rocket cases. Other equipment presently installed at GE includes two 47-by-50-inch hydrospin units and one 68-by-60-inch roll-forging machine.

Tricent steel and roll-forming have been combined in the manufacture of high-quality, large-diameter solid rocket cases. One such case is 44.5 inches in diameter; has a single girth weld; a roll-formed cylindrical section, and machined forward and aft closures with integral skirts, bosses, and ports (no welding). Variable wall thicknesses have been used throughout the design to obtain minimum weight for optimum performance, especially on end closures. Several cases have been hydrostatically tested to 190,000 psi hoop stress. Other work indicates that 230,000 psi hoop stresses can be achieved reliably. Welding techniques have been developed that provide joints with properties approaching those of parent metal.

• **Barrier falls**—We are now convinced that the so-called 200,000 psi design barrier is fictitious. Advanced programs are under way to study the mechanical behavior of metals under complex and combined stresses, so that adequate and accurate design stresses can be established. Other work under way shows promise of providing 300,000 psi design stresses with alloy steels for the near future, and perhaps as high as 400,000 psi ultimately.

This potential is provided by the deformation of steels in the metastable austenitic condition. The process is known as aus-spinning. In this process, the spinning preform is austenitized at about 1700°F., cooled rapidly to a temperature in the deep-bay region (800°F—1000°F), roll-formed to desired reductions, quenched to room-temperature, and tempered to develop suitable strengths and ductilities.

Work to date has been conducted on many experimental steels and on commercial compositions such as Super-Tricent, Halcomb 218, and La-Belle HT. A wide variety of strengths and ductilities can be obtained by varying the amount of reduction, the spinning temperature, holding times, and tempering cycles. Ultimate tensile strengths have approached 400,000 psi in some cases, and 0.2% offset yield strengths approach 360,000 psi.

The properties of aus-spun Super Tricent are especially attractive. At the 300,000 psi yield strength level, tensile elongations are about 15% in 2 inches. Normally, in conventional heat treatment of steels, strength is increased only at the expense of ductility. Work on other materials have produced tensile elongations as high as 20% with 0.2% yield strength of 320,000 psi.

• **Solid rocket nozzles**—The performance of present nozzle components is limited seriously by the lack of structural materials. Work during the last 10 years has centered principally on using ceramic, metalloid, and cermet materials. These materials have generally proven inadequate because of lack of thermal and mechanical shock resistance.

CASTING OF a truncated, cone-shaped portion of a re-entry vehicle thermal shield of new GE ablation material.

Work in the U.S. during the last three years has concentrated on development of refractory metals for components that are in contact with hot exhaust gases. These metals include molybdenum, tantalum and tungsten. Although the oxidation resistance of such metals is poor, high-temperature oxidation is often not a problem since exhaust gases present neutral or reducing conditions. The advent of aluminized propellants has presented some serious problems because of deposition products which react catastrophically in some cases with the structural component. With other propellants, highly localized oxidizing conditions can result in serious deterioration of nozzle walls.

The melting point of the structural material is an important design criterion for uncooled nozzles where minimum weight is desired. Since tungsten has the highest melting point of all metals (6170°F), it promises the greatest potential for designing solid rocket nozzles. However, the high density and high thermal conductivity of tungsten prevent the use of all tungsten nozzles. Rather, nozzle designs must employ thin shells or liners of tungsten which are backed up by lightweight, thermally insulating materials. Such backup materials may include constituents such as ceramic oxides and graphite.

• **Work hot**—The ductility of tungsten and molybdenum is quite low at room temperature, but even this limited ductility is still several orders of magnitude higher than that possessed by refractory non-metals. Above the ductile-brittle transition temperature (400-600°F), tungsten and molybdenum are quite ductile and fabricability increases with increasing temperature. However, fabrication of these metals presents very serious problems where complex shapes are involved.

Metallizing processes for coating components with refractory metals are quite attractive. Components of complex geometry can be fabricated easily and economically within certain limitations. Until recently, conventional metallizing processes used hot combustion flames, obtained by burning suitable fuels with oxygen or air, to melt and carry molten particles to the work piece being coated.

Two other methods have been developed in the past two years. One method employs the generation of very high-temperature plasmas (up to 30,000°F) for spraying metallic powders. The other method involves melting metallic wires in a high-intensity electric arc; molten particles are carried to the work by cold gases. The latter Libby "arc-spray" gun was developed in our laboratories.

A wide variety of configurations can be processed with the versatile arc-spray gun. Parts can be built up easily by depositing molten particles onto appropriately shaped expendable mandrels. Mandrels can be removed later by machining, solvent dissolution, or other suitable means. Parts can subsequently be heat treated, fabricated, machined, etc. Metals can be deposited on a wide variety of materials including graphite, other metals, ceramics, and plastics.

• **No "stick"**—It is desirable to coat internal surfaces of graphite nozzle bodies directly to minimize processing costs. However, tungsten deposited directly on graphite does not have adequate adherence to withstand the high-velocity, high-temperature gases in nozzles, because of the formation of brittle tungsten carbide. Accordingly, rhenium plating and processing techniques have been developed to deposit thin bond layers of rhenium onto graphite, on which tungsten is subsequently deposited. Rhenium does not form a carbide, and also acts as a particle barrier to retard diffusion of carbon into tungsten.

This W-Re-Gr system has proven very successful as nozzle bodies in high-performance solid propulsion motors. Early design and processing problems limited performance, but recent modifications have justified this system completely.

nuclear needs to be even stiffer . . .

Rockets Must Be Lighter, More Reliable

by L. L. Gilbert

L. L. Gilbert is the head of the Materials and Process Department, Azusa Operations, Aerojet-General Corp.

AZUSA, CALIF.—The most critical materials and processes fabrication problems facing the missile industry today and for the next decade are dictated by:

1. Operational environments,
2. Design specifications (which are primarily a function of a specific mission for which a particular system is designed), and
3. Increasingly stringent reliability requirements.

The problems of the next one-to-three years are those based predominantly on chemical rockets and the problems of the next ten years will be a combination of chemical rocketry and more advanced types of propulsion systems, such as nuclear, plasma, ion and photon engines.

In chemical rockets today, two basic problem areas exist; improved reliability and reduced inert weight—particularly propellant tanks, nozzles, controls and electronic components, pumps, gears, and turbines. The most critical and immediate need is to devise solutions for reliability and reduced inert weight in the distinct functional areas (1) solid motor cases or liquid engine tankage (pressure vessels), and (2) thrust chamber nozzles.

- **Pressure vessels**—The ultra-lightweight requirements for solid motor cases have opened a completely new field of problems in the high-strength materials such as aluminum, titanium, stainless and alloy steels. Recent studies have emphasized that the reliable use strength level is limited by the inherent toughness or notch sensitivity of the material and that toughness decreases as strength is increased. Thus, reduced weight (increased strength) and increased reliability (increased toughness) are opposing requirements. Present alloy steels, for example, are notch sensitive above about 200,000 pounds per square inch yield strength. Notches or flaws can be reduced by utilizing ideal fabrication techniques. But the small improvements achieved by improved fabrication do not satisfy the ultimate requirement of still lower weight vessels.

The question of what makes high-strength material behave in a brittle manner must be answered. Studies, many of them of a basic research nature, are necessary to provide answer to this question. Rapid and economical laboratory tests to predict pressure-vessel behavior must be devised. This knowledge is needed to develop new materials and new processes of making, shaping, and treating alloys to achieve the maximum theoretical combination of strength *and* toughness.

Environmental conditions complicate the solution. Cryogenic propellants require tank materials of high strength and toughness to temperatures of –420°F. Materials useful at room temperature may not be useful below room temperature because strength and toughness are temperature-dependent. Corrosive propellants require compatibility with tank material.

The use of glass filament-reinforced plastics for pressure vessels offers a potential extremely high strength-density-ratio material. However, the necessity of local reinforcing when the process is applied to complex configurations often results in a drastic reduction in strength-density ratios. Further research and development to extend the processing technology of glass filament-reinforced plastics to complex pressure vessel configurations offers a potential solution to the solid-rocket chambers and liquid-engine pressure vessels where environments are compatible with this composite material.

STEEL CASING fabricated for Aerojet by Kaiser Metal Products using hydrospin process.

Lightweight insulations must also be developed to protect pressure vessels from detrimental effects of aerodynamic heating or to prevent external heat effects detrimental to the propellant.

- **Nozzles**—The present combustion temperatures of solid and liquid propellants are approximately 5500°F. Within the next several years propellant temperatures will range from 6500°F to 8500°F. Uncooled nozzles are already operating near the maximum temperatures for solid materials. Increases in firing time are also expected. This combination of time and temperature requires development of liquid film cooling and endothermic cooling methods—the latter possible employing composite materials consisting of refractory skeletons "married" to ablative materials having high specific heats, heats of fusion, dissociation and vaporization.

Composite materials studies would include means of protecting graphitic materials from erosion and oxidation—something more than a coating since most refractory coatings to date exhibit lack of reliability when subjected to impingement of entrained particulate matter in the propellant stream under extended firing durations.

- **Next decade's problems**—The problems of the next decade will be dictated primarily by the extension of missions to include intraplanetary space probes requiring long firing times, start up in flight, and extremely reliable thrust control for soft landings. Future propulsion systems will include nuclear rockets operating at very high temperatures, plasma engines of low thrust and very long firing times, ion engines of equally low thrust, and—possibly at the very end of the next decade—photon engines.

Nuclear fuels are essentially limited to uranium, plutonium, and thorium. The more desirable propellants would include hydrogen, helium or other light gaseous materials. The major problems appear to be those of compatibility of the fuel material and its accompanying radiation with container, heat exchanger and the structural materials at ultra-high temperatures, and the development of fabrication techniques for providing complex fuel element shapes of reasonable economy and high reliability.

• **Reliability needs**—It might be said that the reliability requirement of nuclear propulsion systems is one order of magnitude greater than that of chemical systems. Abortive missions induce considerably greater hazard to terrestrial ecology and can completely inactivate firing stands and launch areas in case of catastrophic failure. The necessity of careful selection of materials with respect to nuclear cross-section, nuclear economy and high-temperature capability seriously limits the materials choice.

The use of beryllium, its alloys and compounds, graphite, the reactive metals and in some cases thin sections of the refractory metals, implies development of fabrication techniques and materials properties beyond the present state of materials technology. For very long missions, it is conceivable that propellant storage tanks of very large dimensions (30 to 40 ft. diameter, 100 to 200 ft. long) would be required to provide propellant for round trip flights.

The ion, plasma and photon engines are still mainly theoretical. However, corrosion problems presented by the highly reactive propellants (cesium, lithium, etc.) and the sputtering erosion or radiation damage inherent in ion or plasma engines require extensive investigation to make them operational.

The Growing Role of Materials Engineer

by N. J. Hoffman and D. E. Roda

CANOGA PARK, CALIF.—Rocket engine technology has begun to edge out from the domain of the mechanical engineer, chemical engineer, and stress analyst.

Exotic propellants, daring propulsion concepts and unique environmental conditions are pushing rocketry into some of the physicists' ivy-covered realms, such as the solid state, nuclear, and plasma technologies, into the chemists' research laboratories and directly into the province of the materials engineer. The only limitations of the rocket engine are the limits of man's imagination and the limits of the materials from which the hardware is constructed.

The problems associated with materials for this generation of liquid-fuel rockets are rapidly being solved. The most pressing problems are concerned with the joining of high-strength, corrosion-resistant alloys in the heat-treated condition. There are many obvious problems requiring study by liquid rocket engine materials engineers, such as compatibility, anti-galling characteristics, high-temperature physical and mechanical properties, and fatigue life.

Other areas requiring study are not so immediately obvious. These include such items as cleaning and passivating procedures; physical and mechanical properties at cryogenic temperatures, especially relative thermal contraction data; safe utilization of low-ductility materials, lubricants, bearings and seals that must work under very extreme environmental conditions; and catalytic properties of materials.

• **Very low temperatures**—In advanced liquid rocket engines, exotic propellants, such as liquid hydrogen fuel and liquid fluorine oxidizer, accentuate the materials problems present with conventional propellants. Materials for seals, lubricants and cleaning procedures are two areas that do not allow the materials engineer to rest easy when he handles liquid fluorine. The lack of cryogenic property data around −423°F and safe use of brittle materials loom darkly on the horizon while he contemplates liquid hydrogen.

Solid propellant rocket engines of high specific impulse present several rather difficult problems to the materials engineer. Demand for very light casings of high strength-to-weight ratio has led to the use of extremely high-strength steels fabricated with new techniques. This technology is so new that the background for designing and fabricating with these very-high-strength steels is still not on a scientific basis.

Nuclear heat transfer rocket engines are around the corner, according to nuclear physicists and mechanical engineers. If the nuclear heat transfer rocket is going to employ an epithermal or thermal reactor made from graphite and uranium carbide, the materials engineer is going to have to hustle. Today, although the black art of making graphite in the United States is in rapid transition, the lack of an adequate graphite technology is a major obstacle to this type of nuclear propulsion. Variation of mechanical properties from lot to lot, major joining problems, and the general unfamiliarity of private industry with this material as a structural member, are part of the graphite picture. The most important step, dissemination of knowledge on the processing technology of graphite, will have to begin.

N. J. Hoffman is a Research Engineer and D. E. Roda, a Group Leader, both of Rocketdyne, a Division of North American Aviation, Inc.

• **Nuclear radiation**—Effects of radiation on materials, especially plastics and electronic equipment, are another major problem. Suitable materials for moderators, shields, and reflectors, will have to be studied.

The ion rocket engine system radiator will present some of the knottiest materials problems: in the field of selective spectral surfaces; long-time creep properties of the refractive metals; and the many problems inherent with proximity to a nuclear pile power source.

Any propulsion system operating in outer space will tax the materials of its construction in rather unusual ways. The high vacuum of outer space may alter surface properties of the metal hardware. Protective oxide films may disappear, causing metal surfaces in contact with each other to weld together. Materials containing dissolved gases may release these gases with serious results. Corpuscular radiation from the sun may cause hardware to sputter away over long periods of time. Cosmic radiation may drastically affect plastics and the ability of some metals to withstand triaxial stress.

• **Space sandblasting**—Meteoroid damage to materials will be a very large headache. Solid particles of rock or iron-nickel alloy will impinge on the hardware at velocities in excess of 30,000 feet per second. At such speeds,

SEASONED IN THE SERVICE

William Wheeler, vice president in charge of Motorola's Military Electronics Division discusses participation role in the B-70 project being developed for the Strategic Air Command at North American.

"North American's pre-award analysis and evaluation, before awarding the contract for the Mission and Traffic Control System of the B-70 Valkyrie to Motorola, was one of the most thorough and extensive ever made."— North American Aviation, Inc.

On the next two pages: Motorola's Seasoned Military Service Record.

Since before World War II, Motorola has demonstrated its exceptional ability in military electronics on assignments that include communications equipment . . . radar . . . missile guidance . . . data processing and display . . . antisubmarine warfare . . . demonstrating with each success the value of a technical task force that is . . .

Roy Olson, general manager of Motorola's Chicago Milit
Electronics Center, which emphasizes work in surface and s
surface electronic equipments and systems.

Seasoned in the service

Hundreds of thousands of Motorola walkie-talkies were produced for World War II combat use.

Few weapon systems now under development are expected to play as important a role in U.S. defense in the coming decade as the B-70 Valkyrie. This fantastic new weapon will cruise at more than 2000 m.p.h. at altitudes over 70,000 feet.

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High-level responsibilities such as this are not new to Motorola. It was in June of 1940 that the prototypes of the history-making Motorola walkie-talkie were delivered to the U.S. Army Signal Corps. During World War II, Motorola not only supplied vast quantities of equipment that kept advancing U.S. ground troops in constant communications, but was also chosen by the Signal Corps to direct and manage the supply of the entire U.S. Army's need for electronic crystals. These critical frequency-determining components were vital to radio communications.

In the late forties and early fifties it was weapon fuses, radar bombsights and tactical microwave communications. Today, in company-owned research and production centers across the country, thousands of Motorola engineers and scientists are at work on a broad range of military projects. Included are missile guidance, high-resolution radar, sonobuoys, the next generation of equipment for radio-telephone communications between ground troops, and advancement of the frontier of knowledge in solid-state electronics.

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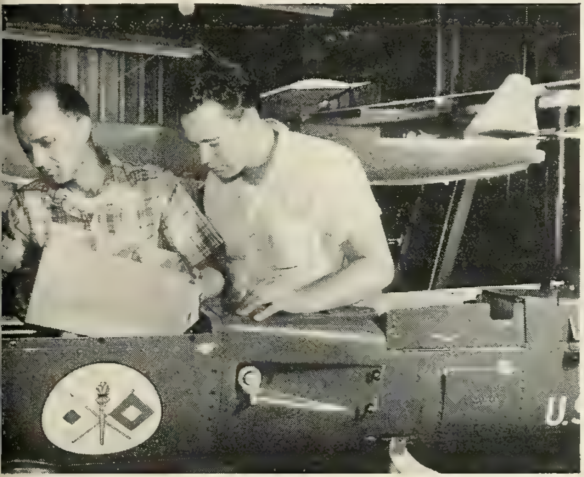
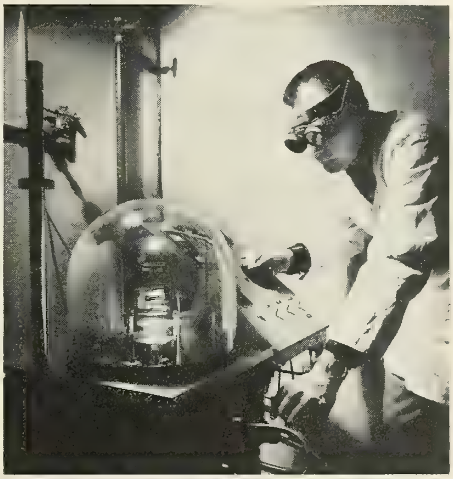
Joe Chambers, Motorola vice president and general manager of the Western Military Electronics Center, directs Phoenix laboratories concerned primarily with work on sophisticated airborne and spaceborne electronics.

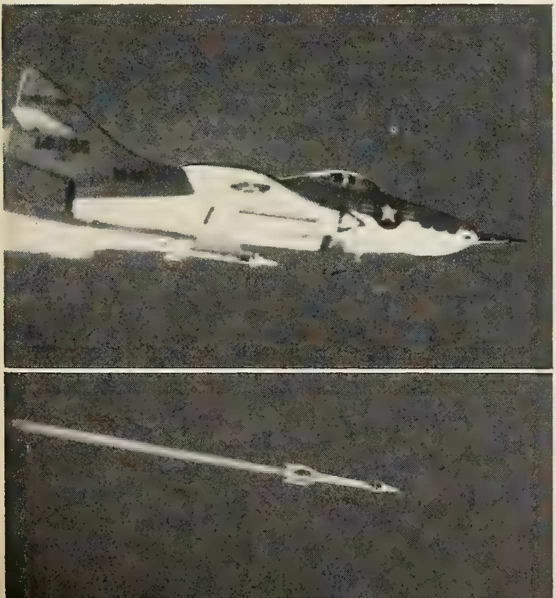
John Byrne heads highly classified advanced study and developmental work on a wide variety of military contracts at Motorola's Systems Research Laboratory, Riverside, California.



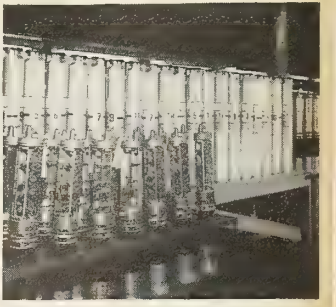
Development of passive seeker by Motorola, Riverside, is under contract to the Signal Corps for use with U.S. Army drones capable of performing night, day, and all-weather surveillance.



Motorola's surging capabilities in the solid state electronics art is achieving new dimensions in complexity, performance and reliability for new electronic concepts.



Inspection, the eyes of quality control, helps convert experience into reliability at Motorola.



AN/SSQ-23 Sonobuoys for the antisubmarine warfare program in volume production at Motorola Chicago.

Motorola is making significant design contributions to advanced guidance head for Sidewinder air-to-air missile which is under fabrication at Phoenix laboratories.

diamonds where none should be . . .

HUGE TEST STANDS such as this one at Rocketdyne's Propulsion Field Laboratory in Santa Susana mountains, hold engines captive during ground firing tests.

new phenomena may possibly occur. Mineralogical investigation of meteorites have shown diamonds present in structures which were apparently under pressures too low for diamonds to have been formed. Perhaps the pressures resulting from fantastically high-velocity small meteoroid particles colliding with large meteoroids changed carbon into diamonds.

The phenomena resulting from such collisions should be studied by the materials engineer in the hope that some method, such as "bumpers" of some material may alleviate damage. The relationship of alloy structure or material properties to meteor damage alleviation is one of the major problems of the future for the space vehicle materials engineer. At present, the problem looks very difficult, but a few short years ago, the re-entry problem seemed completely insoluble.

Today, the materials engineer acts as consultant on complex materials problems that tend to limit severely the design engineer. Tomorrow the materials engineer will have to supply the very launching pad before the preliminary designer's imagination can soar into tomorrow's tomorrow. A greatly expanded research effort will be required.

Missile 'Innards' Must Take Space Rigors

by Frank McGinnis

GREAT NECK, N.Y.—If we hurled nothing but nose cones into space the materials research people could go back to their golf.

The cone may glow, peel, and erode but the material retains shape, most of its body, and all of its function. This materials problem has largely been solved. But behind the nose cones lies a host of seething components, instruments, and payloads which must live and function in a hostile environment of extreme temperatures and caustic radiation. Using available materials we are in the position of sending boys to do men's jobs.

Anticipated temperatures in uninsulated compartment areas of reentrant manned space vehicles run to several thousands of degrees F. Many materials, which shrug off radiation fail dismally when faced with heat. Beyond 300°C the elastomerics, so perfect for gaskets and seals, must be discarded. Less than perfect rigid materials must be used.

Long term stability is a necessity for materials used in satellites and in missiles maintained in readiness over long periods. With the exception of a few non-polar compounds (polyethylene tetrafluorethylene) the thermoplastics must be eliminated. There are substitutes for the thermoplastics but most of these are susceptible to temperature extremes.

Guidance systems employing floated gyros demand a flotation fluid that remains fluid. The fluorovinyl chloride family, often used in inertial components, solidifies at room temperature. This can cause internal damage and also requires long warm-up time. To alleviate this particular problem we at **Sperry** have developed a bromo-derivative fluid, Gyrolube Flotation Fluid, which remains in a plastic state to –65°F. This is not the ultimate answer.

The heart of many guidance systems is a grouping of gyros and accelerometers coping with vast distances and extreme accuracies. Measurements on the order of 5 to 10 millionths during fabrication are hardly sufficient. Stability of material after measurement is imperative. Closest to the ideal structural material—combining weightlessness, infinite modulus of elasticity, and dimensional stability—is beryllium. Unfortunately this material presents a health hazard in handling. It is also brittle, difficult to fabricate, fusion weld and braze. In its favor is a melting point of 2345°F making it useful structurally when aluminum (1200°F) and magnesium (1100°F) are liquid.

Mr. Frank McGinnis is the Director of Reliability and Quality Control at Sperry Gyroscope Company, Great Neck, N.Y.

• **Friction question**—Figuring prominently in inertial guidance problems are ball bearings. It has been found that, during fabrication and sizing, minute contaminant particles are introduced into the bearing. When marginal lubrication, necessary for design application, provides a film thickness of merely 1/10 of a micro-inch, the particles of aluminum oxide or other abrasive material can easily be larger than the oil film. During rotation these particles are associated with a release of heat or electrical energy causing a chemical change in the lubricant. Operational usefulness becomes marginal and a new lubricant desirable.

In rotating electrical components, slip ring assemblies add woes to the picture. Organic materials in the air can cause polarization of materials on the slip ring surfaces forming a varnish resulting in open circuits. Wear of brushes and rings seems to be perpetual. A protective coating is needed to prevent varnish formation and minimize wear without harming the electrical function. We are endeavoring to develop materials which are compatible wear-wise and will provide good electrical continuity.

Printed circuit boards suffer under Space Age heat and radiation. Dimensional stability is affected by expansion and contraction. The physical structure (fibrous) prevents subminiaturization by limiting placement of holes. Glass epoxy materials are good only to 150°C and solder techniques must change with solder being liquid at 361°F. Bare copper oxidizes at 500°F. For the board itself, glass or ceramics may be future hopes but machining and fabrication are difficult. Ceramics may well prove to be a rich field for many materials research problems.

• **More study needed**—A long-range view would seem to indicate need for accelerated research in the field of solid and liquid state physics. Recently we have seen ferrites, transistors, cryotrons and MASERS developed. Other components presently under study, and dependent for their operation upon the physics of materials, are nuclear resonators, non-reciprocal circuit elements such as gyrators, and passive elements whose impedances vary with fractional powers of frequency.

In its present form the cryotron is limited to low-frequency operation but a number of generic forms being developed promise great size reduction and higher frequency capability. Noteworthy are the cryotrons made by vacuum deposits of successive layers of superconducting and insulating materials on a dielectric substrate.

This statement of requirements represents a shopping list for the American industry super-market. It has been said that materials are not everything. The reverse is true for missiles and space travel.

Materials Will Have To Outdo Themselves

by Dr. George J. Mills

Dr. George J. Mills is manager, Materials Department, Space Technology operations, of the Aeronutronic Division, Ford Motor Co.

NEWPORT BEACH, CALIF.—The availability, production and application of materials is far behind our capability in systems and component design. This is due, in part, to the physical and technological separation of design, development, and testing on the one hand and materials research and development on the other.

What the limiting materials performance capabilities may eventually be are not now easily defined. We are still uncovering or distinguishing environmental conditions at a far faster rate than materials technology can satisfy.

The great variety of material performance requirements have directed attention to composite structures in which each component performs a function for a prescribed time period. The future is not as easily satisfied since we are asking of materials things that presently appear to be beyond their inherent nature. For example:

• **Ceramics**—Some of the more critical problems facing the missile industry in ceramics are: (1) tailoring combinations of ceramics with other types of materials to withstand environments of increasing severity; (2) improving or creating fabrication processes to produce structural ceramics possessing optimum and reliable physical properties; and (3) improving the understanding of the fundamental behavior of ceramic and allied types of materials.

Of the materials for rocket liners and nozzles, re-entry nose cones and leading edges, no one possesses all the required properties—such as thermal shock resistance, thermal insulation, high strength, corrosion resistance, etc. This establishes a need for composite structures.

The fabrication of large ceramic structures is a relatively new requirement calling for original creative thinking. Ceramics that are structurally sound and reproducible are required for engineering applications. Techniques must still be developed for nondestructive testing of ceramic structures.

From a long-range viewpoint, better understanding of the fundamental behavior of ceramics is needed so that the knowledge can be applied to practical problems. Theories based on atomic dislocations which can clarify such areas as deformation and diffusion are an example.

• **Metals**—Steel is the most important high-strength structural alloy. However, the technical evolution of modern high-strength steels has not kept pace with aircraft and missile design requirements for higher strength-to-weight ratios.

Another important problem is protection of refractory metals against oxidation. Tungsten, tantalum, niobium and molybdenum give promise as ultra-high-temperature structural materials. Unprotected, however, catastrophic oxidation occurs at temperatures as low as 1500°F. For molybdenum there have been developed some coatings that give a significant measure of protection in the 2000-2500°F. range. However, these silicide-containing layers suffer disqualifying instability in the 1200-1700°F range. A stronger integrated attack on this problem through basic research is vitally needed.

In recent years there has been great progress in mechanical properties testing. Ultra-short time and ultra-high-temperature creep-rupture data is available for most well-known engineering alloys. Hot hardness testing is a common metallographic tool. Modulus-of-rupture data are published for many materials, at least up to 1500°F. However, a serious problem is the lack of a definitive test for pressure-vessel failure synthesis. Neither impact nor notch-sensitivity tensile tests can duplicate stress biaxiality. Correlative data are lacking to explain either the mode or the manner of premature failures in pressure vessels.

• **Plastics**—The demand for plastic materials with improved properties has increased from the range 200°F to 650°F, such as encountered in high-speed aircraft, to 5000°F to 10,000°F, such as required in modern space vehicles. Particular emphasis has been stressed on materials with superior properties of ablation, thermal insulation, and high strength-to-weight ratios.

Although only satisfactory as compromises, ablation plastics have been obtained through utilization of improved phenolics, phenolic-silanes, and nylons, in combination with reinforcements of high-silica content, asbestos, and graphite fiber. However, there is still considerable research and development necessary in ablating materials in order to attain the goal in ablation plastics, i. e., the largest amount of heat absorbed per unit weight of ablator.

Probably the greatest area for future research and development will be in knowledge of plastic materials' behavior for long time periods under extreme vacuum and space environments. But first the design engineer must provide information on the operational requirements of space vehicles and their effects on plastic materials.

in propulsion and casings . . .

Pushing Up I_{sp} Brings Fresh Problems

by Dr. Morris A. Steinberg

SUNNYVALE, CALIF.—The most critical immediate materials problems facing the missile industry today concern propulsion and motor casings. Problems in these areas are going to become even more horrendous.

With the aim for higher specific impulse and with the development of better solid propellants, fuel compositions tend toward higher metal content additives. This helps increase specific impulse but also raises a large number of additional problems.

The high temperatures associated with these systems cause vaporization of normally solid reaction products. Their dissociation can also produce finite rates of side reactions. If condensation recombination, and re-establishment of equilibrium is not achieved in the nozzles of high-performance engines, associated energy losses will cause a significant reduction in propellant performance. Chemical kinetics and supersonic flow in nozzles must be explored both analytically and experimentally in order that propellant systems can be optimized to yield the greatest specific impulse.

New schemes of nozzle construction must be rigorously investigated because of the tremendous materials problems that will be associated with the next generation of solid propellants. These include film cooling, ablation, transpiration cooling, etc.

- **New approaches**—The development of ultra-high-strength motor cases consistent with operational pressures and structural integrity, and the development of lightweight plastic-type motor cases are a prime necessity for both missiles and boosters for spacecraft. New approaches, such as shear-spin forming, improved steels and improved welding techniques are of paramount importance.

New concepts in plastic laminate structures, consistent with reproducibility and high strength, should be investigated rigorously. New concepts in refractory metal-organic laminate structures, and methods of laminating refractory oxides with materials that will insure structural integrity for some of the inert components in the propulsion system, are of major interest today. Finally, insulation materials better than those presently available must be developed.

Dr. M. A. Steinberg is Manager of the Materials and Propulsion Research Division of Lockheed Missiles and Space Division.

Although there have been significant advances in overcoming the atmospheric re-entry problem, much more remains to be learned—use of ceramics as refractory coatings for other refractory metallic materials, for instance.

The inherent brittleness of ceramic materials—and the difficulty of producing large shapes of complex design—limit their usefulness in certain critical applications. However, we are counting on new fabrication techniques to yield products that can be used. For example, metal-reinforced ceramics: filaments of the refractory oxides fabricated by filament wrapping techniques and bonded with inorganic materials, capable of withstanding higher temperatures than present resin-bonded fiberglass structures.

As concerns re-entry bodies, a better understanding of the ablation process would seem one of the major research activities that must be undertaken. We should investigate the potential use of *inorganic ablators* to absorb larger amounts of heat, with these ablators having very high "Q" stars (BTU/lb).

- **Vacuum effects**—One final major area of activity that I would like to stress is that of surface effects in spacecraft materials. Surface phenomena are among the least understood of reactions involving materials and their interaction with their environment. The affect of prolonged exposure of materials to the vacuum of space presents a large new field of endeavor necessary to navigation in space.

Low vapor pressure alone will not assure permanent dimensions, particularly with sufficient heat input to materials. Absence of gas films will permit sizing and galling of sliding or contacting parts. Lubrication in space will present greater problems and will be more generally required than in the earth's atmosphere.

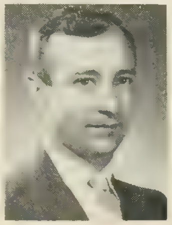
The effects of ascent heating, solar ultraviolet radiation, vacuum, micrometeorite bombardments, Van Allen radiation, and molecular bombardments should be investigated so that proper preparation can be made of these surfaces to assure temperature control being exercised at all times. In addition to flight environment effects on surface emissivities, the shop environment must be taken into account. It is needed to determine manufacturing controls.

Coping with High Flame Heat

by Eugene L. Olcott

ALEXANDRIA, VA.—In general the hardware on solid-propellant rockets has gone through three historical phases of development.

Solid propellants employed in the barrage rockets of World War II burned with high flame temperatures. Heavy hardware and the accompanying heat-sink effect were employed to obtain endurance of materials in these flames.



Eugene L. Olcott is director of the Materials Division of Atlantic Research Corp.

The next stage of development saw the use of propellants with lower flame temperatures so the hardware could be lightened, thus increasing missile performance.

The latest phase of development is a return to high flame temperatures to increase propellant performance, maintaining light hardware to retain its missile-performance advantages. It is this combination of high flame temperatures and light hardware—together with other advances, such as increased burning time and pressure—that presents challenging materials problems.

Considerable progress has been made. It is interesting to note that designers of liquid-propellant rocket

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motors are considering materials ap- [illegible] used for solid-propellant motors in lieu of regenerative cooling.

The most critical problem areas in a solid-propellant rocket motor are (1) the motor case, (2) the motor-case insulation for high-performance end-burning motors, and (3) the nozzle insert. For nominal operating conditions, some of these problems are readily solved with current materials technology.

- **Motor case**—The problem of minimizing motor-case weight (while containing the high internal pressure) has been partially solved by the use of high-strength alloy steel. Alloy steels have poor resistance to crack propagation when heat-treated to an ultimate tensile strength above 240,000 psi. However, this fault can be overcome by heat-treating below this strength level.

- **Motor-case insulation**—Motor-case insulation in an end-burning rocket is a particularly severe application for materials. Parts of the insulation are in contact with hot combustion gases for the full burning duration. The steel motor case must be insulated to maintain a temperature below 600°F. The insulation must form with the motor case without cracking under internal pressure. In the *Iris* sounding rocket, for example, motor-case insulation weight is only 5% of the propellant weight. Even further weight reductions are planned by using less of an improved modified-epoxy system.

- **Nozzle insert**—The material problem encountered in designing a nozzle insert is a particularly difficult one. Here exist all the complications of chemical reactivity, erosion, thermal shock, differences in thermal expansion of mating parts, and fabrication. The surface of the nozzle insert closely approaches the gas temperature, since it must be insulated from the structural parts of the rocket motor. Refractory metals and alloys have limited applications.

In these instances, design problems are further complicated by the poor thermal shock resistance of ceramics. On the other hand, high-temperature strength has not been a critical factor when adequate support of the nozzle insert is possible.

We will have to use brittle and difficult-to-fabricate materials. The highest attainable strength-to-weight ratio for structural parts will continue to demand attention. Hopefully, continuing advances in materials technology will furnish further improvements in materials performance before we will be forced to resort to cooling or other involved means of alleviating the materials problem.

Call for Scientific Approach

by Coleman Raphael

FARMINGDALE, N.Y.—In the evolution of the aircraft and missile industry, the development of materials to meet specific needs has generally been treated as an art, rather than as a scientific branch of a technical industry. Now, with the sudden rapid strides of missile and rocket development, and the advent of a new technological field, astronautics, the need for a more scientific approach to material development is clearly indicated.

One of the critical shortcomings associated with today's materials is the lack of information concerning their properties. A typical example of this was evident recently with the sudden popularization of titanium, the "wonder" metal. Everybody "wondered" how it could be used efficiently. The manufacturers who were producing titanium alloys (at premium prices), while publicizing their light weight and high static strengths, had essentially no information concerning their properties in fatigue, impact, creep, and various thermal environments.

A much more desirable approach to the materials problem is one in which the requirements are first specified, and then the combined talents of the chemist, metallurgist, and physicist are directed toward the development of a material to satisfy these requirements.

Many techniques are available for production of desirable mechanical and physical properties. The organic chemist, for example, is able to select radicals and form molecular chains that will synthesize compounds having specified characteristics. The metallurgist knows the effects of small amounts of alloying elements on crystal structure, the way that grain size and distribution affects properties, and the variations of grain size with heat-treatment and cold-working techniques. By directing a concerted effort toward the utilization of these techniques, it should some day be possible to design a material "to order," to meet the requirements of manufacturing simplicity and reliability in withstanding its environment.

Coleman Raphael is Manager, Advanced Projects, for the Missile Systems Division of Republic Aviation Corp.

- **Temperature barrier**—Most of the major obstacles to astronautical development in the next decade fall within a single category: the need for withstanding sustained high temperatures. For example, the performance of a rocket engine is critically dependent upon the specific impulse of its fuel. Today we are using specific impulses of about 240 in solid motors with the ability of making a sizeable increase by the addition of suspended aluminum particles to the fuel. In the future, with the use of lithium and other high-energy fuels, it will be possible to make tremendous increases in rocket performance.

However, specific impulse is proportional to the square root of chamber temperature. To make efficient use of lithium fuels, it will be necessary to bring chamber temperatures to over 6000°F (with proper oxidizers chamber temperatures could reach 8000°F). The problem will then be the development of rocket engine liners, nozzles, and launching platforms to withstand these temperatures. Today, using ablating Refrasil liners, the maximum chamber temperatures which can be withstood satisfactorily are in the range of 2000 to 3000°F.

Vehicles that are to fly within the atmosphere at high supersonic or hypersonic velocities will be subjected to external skin temperatures as high as several thousand degrees. It is, therefore, necessary to have materials that can withstand these temperatures, simultaneously carrying air loads and being able to deform with the structure. The most promising materials for resisting temperature over 2000°F are the refractories and their alloys—tantalum, molybdenum and tungsten. However, these materials are at present too brittle to be worked or machined. One of our major problems will be to increase their ductility and adaptability to aircraft and missile manufacture.

To find solutions to these problems, we should abandon our present custom of developing new materials, marketing them, and then investigating their properties. Instead, we should begin to seek *an understanding of the fundamental characteristics of materials on a molecular and submolecular basis, so that it may someday be possible to tailor the design of a new material to its specific requirements. A major research program in this direction will probably require government support, but the results should be well worth the investment.*

No Magic Materials in Sight

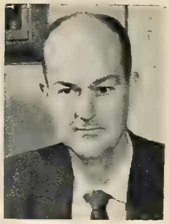
by John L. McDaniel

HUNTSVILLE, ALA.—The most critical materials problems facing the missile industry today and upcoming in the next decade in the area of field Army weapons may be broken down into three major categories:

1. Missile structures that achieve adequate compressive strength with minimum weight.
2. Solid-rocket motor cases that attain a very high strength-to-weight ratio within a moderate temperature environment.
3. Lightweight materials to withstand the environment of the exhaust products of solid-propellant rocket motors.

In the case of the solid-propellant rocket, the motor cases must withstand the loads from the internal pressure of the combustion and those from aerodynamic loads. To reduce the weight of the casing materials, designers have allowed for stresses that just about equal the maximum yield strengths that can be realized with steel.

It is with these high-yield-strength steels that the problem of brittle failures has become paramount. While this brittle nature of the steel may be tolerated in a motor case, it is a limiting factor in dome ends that contain thrust reversal mechanisms or ports, thereby setting up areas wherein the stresses cannot redistribute themselves because of the brittle nature of the steel.



John L. McDaniel is assistant technical director of the Ordnance Missile Laboratories Division, Army Rocket and Guided Missile Agency.

• **Material limits**—The combustion products from the rocket motor are exhausted through a nozzle carefully designed to control the thrust. The greatest gains in performance and economy for future field army weapons will be realized through higher gas temperatures. The gains are limited today by the strength of structural materials at high temperatures.

A major challenge in the next decade is to provide structural materials to use in a nozzle exhaust environment of 7000°F for durations up to 100 seconds. In addition to withstanding the high thermal flux from the exhaust gases, the nozzle divergent section is also the structural member to which a variety of vector control devices may be attached, so this member must also have adequate section modulus and strength at the elevated temperature.

The most critical materials problem facing the missile industry today is one of *engineering*. No magic materials are likely to appear overnight; therefore, systems must be designed around existing materials.

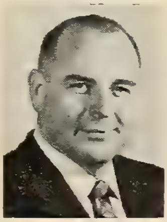
Effects of Environments

by John Van Hamersveld

HAWTHORNE, CALIF.—To evaluate the most critical materials problems facing the missile industry today, and enigmas with which the industry will be faced during the next decade, it is desirable to review some of the environments under which rocket, missile and space capsule materials must operate with a high degree of reliability.

The following four general environments may drastically effect the behavior of the present and future materials:

1. Severe conditions imposed by liquid-propellant, solid-propellant, and nuclear-powered rockets.
2. Conditions imposed by natural hyperenvironments.
3. Conditions imposed by induced hyperenvironments.
4. Conditions imposed by a combination of natural and induced hyperenvironments.



John Van Hamersveld is general supervisor of the Design Support Branch of Norair Division, Northrup Corp.

Developers and producers of rocket powerplants should be more intimately acquainted with materials problems in their field than the rocket, missile or satellite systems developer. Although solid- and liquid-propelled rocket motor materials are subjected to extremely high temperature and highly corrosive fuels, the exposure is usually very short.

Conditions imposed by induced hyperenvironments with which rocket, missile and space capsule builders are faced include the following items: temperatures ranging from about –420 to +6000°F; thermal shock of an entire vehicle caused by re-entry and of components; mechanical shock; acceleration effects; acoustic vibration; mechanical vibration; explosive decompression; and nuclear radiation.

To envision how numerous possible combinations of natural and induced hyperenvironments could affect rocket, missile, and space capsule materials systems requires little imagination.

A study of possible environments reveals that the most critical materials needs now facing the industry include:

- **Optimum materials** system—development of materials that, when combined structurally, act as an optimum integral unit.
- **Structural** metallic, non-metallic, and composite materials that resist temperatures ranging from –420 to +6000°F and that are relatively immune both to electromagnetic and energetic particle radiation.
- **Ductile protective coatings** capable of resisting a wide range of temperatures, and radiation for periods of time ranging from three hours to a year.
- **Low-density** materials that can be utilized in the design of lightweight vehicle structures and payloads.
- **Fasteners** capable of satisfactory service at temperatures of at least 3000°F.
- **More economical** methods for forming metal components. This includes precision explosive forming of super alloys and refractory metals.
- **Techniques** for improved similar and dissimilar metal joining. This includes explosive forming and electron beam welding.
- **Wrought beryllium** products such as sheet, tube, forgings, and extrusions.
- **High-strength, high-temperature** metallic sandwich structures made from refractory and exotic metals or alloys such as molybdenum, tantalum, columbium and beryllium.

[illegible] strength, **high-temperature** [illegible] fabrics, such as woven [illegible] fibers for parachutes and insulating blankets.

- **Plastic forming methods** enabling forgings and extrusion of refractory metals to be accomplished while the materials are in their most plastic solid condition.
- **Sealing materials and systems** wholly compatible with a materials system.

Future Temperature Problems

by Harry A. Campbell

NIAGARA FALLS, N.Y.—Although much publicity is given to the effects of aerodynamic heating of missile nose cones, it appears that designs employing ablation-type materials are suitable for present requirements. The major problem remains that of discovering materials possessing the greatest possible strength-weight ratios over wide ranges of temperature.

Among the metals, molybdenum, tungsten, niobium and their alloys are under extensive investigation. High-strength steels in the 300,000 pounds per square inch range are needed for rocket engine chambers, especially for solid propellants. Means of fabrication of these materials remain problem areas because of the high costs. Welding is of special importance here.

Molybdenum, tungsten and niobium oxidize rapidly at temperatures of 1500°F and above. This could be catastrophic. Search for oxidation-resistant coatings is active. A few promising coatings have appeared but experience is needed with a full-scale structure under load. A reliable method of inspection for the integrity of such coatings is seriously needed.

H. A. Campbell is the Director of the Engineering and Research Laboratories, Bell Aircraft Corp.

Still another set of problems is presented by beryllium, a metal with attractive structural properties.

- **Fabricating problems**—Although beryllium has a low density/modulus ratio, it is difficult to recover and to produce; it is inherently brittle and must be fabricated with great care. Extensive efforts are being made to obtain suitable shapes and develop better methods of working and joining it.

Some astronautical materials problems visible to the next decade can be summarized somewhat as follows:

- **Overcome** the brittleness problem in beryllium.
- **Produce** ductile ceramic materials in large shapes.
- **Find** means to raise the recrystallization temperature for heat-resisting alloys.
- **Improve** resistance to oxidation of heat-resisting alloys with or without coatings.
- **Improve** the strength properties of existing alloys by at least 25%; preferably 50%.
- **Develop** non-metallic large strength-weight ratio materials for continuous service at 1000°F or higher.
- **Develop** light-weight nuclear shielding materials.

Materials To Fit The Needs

by E. J. Dofter

DETROIT—The phenomena surrounding the brittle-fracture of pressure vessels fabricated from high-strength steels constitute the material problem requiring the greatest attention in the missile industry today.

A satisfactory solution that can predict the behavior of steels, particularly at high hardness levels under complex stresses, is still not available. Such a theory is needed. Also, we need a simple laboratory test, results of which will correlate well with service failures of pressure vessels.

E. J. Dofter is the Assistant Chief Engineer, in the Missile Division of Crysler Corporation.

Most other critical missile material problems have their roots in the behavior of the material as it is affected by its environment. By far the greatest volume and tonnage of materials in use today eventually finds its way into a product which is used in ambient environment. As a result, a great amount of data and experience is available in the behavior of materials in these environments.

Materials in the missile industry require that they be used at extremes of environments which were not common even five years ago.

Two courses of action have been pursued in fulfilling missile material requirements. The first has been to develop new materials and alloys to cope with these environmental extremes. The second has been to obtain better data on commercial materials so that they can be better understood and intelligently employed in these new environments. I recommend the latter course of action as being the most productive on the short haul.

- **Common materials**—The majority of materials used in the missile industry are not new. It is their use that is new. It is possible to use common materials in new applications after their properties are well known and correlated with the requirements of the surrounding environment.

The propellants used in the missile industry are, of necessity, materials with great chemical activity, which creates problems of corrosion and explosion in storage and handling. There is a great need of improving nonmetallic polymers, adhesives, and sealants which must come in contact with high-energy propellants such as chlorine-trifluoride, hydrazine and hydrogen tetroxide.

In the next decade, progress undoubtedly will be made in the solution of the above problems; but new problems will arise as the frontiers of space flight are extended. One of the major impending problems about which very little is known is the behavior of ordinary materials when subjected to the hard vacuum of outer space.

The effects of radiation that occurs in space must also be studied. The predicted problems of the next decade, as we see them from our present vantage point, will undoubtedly have to be revised as our space program continues. The VanAllen radiation belt, for example, was not even included in the problems of ten years ago. We must be prepared to face new difficulties as our knowledge of outer space increases, and we should also expect to solve these problems as this knowledge increases.

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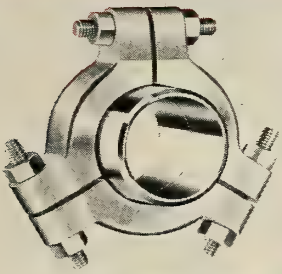

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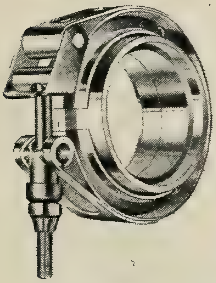

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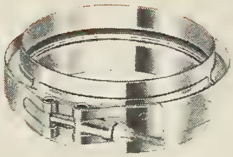

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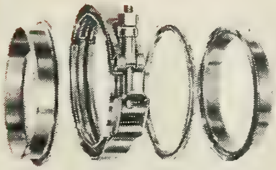

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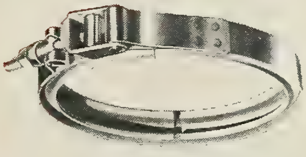

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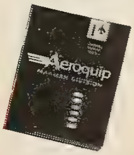

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Hot-nose Missiles Need Better Radomes

Super ceramics are being developed and new fabrication methods make alumina promising for high-temperature uses replacing plastics

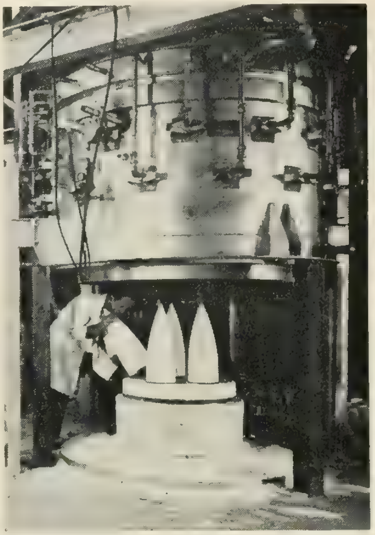
by Hal Gettings

WASHINGTON—Hot-nosed hypersonic missiles pose demands for ceramic materials far superior to those available at present. Air friction heat generated by the high-speed birds practically eliminates conventional plastic noses. Metals, obviously, cannot be used since they are not transparent to radio waves. Much research is in progress.

The radome serves as a protective covering and window for the radar antenna. Its shape—a projectile ogive—is a compromise between aerodynamic and electromagnetic ideals—with electromagnetic considerations the loser. The resulting configuration poses problems in both transmission characteristics and fabrication processes. These problems, not too severe with plastic structures, become especially troublesome in ceramic construction.

First major work in ceramics was by **Corning Glass** which developed Pyroceram radomes now used on the *Tartar* surface-to-air missile. Now considerable research is being done with alumina (aluminum oxide), a metal oxide that produces a ceramic with all the required characteristics of missile radomes. Both Corning and **Raytheon** have apparently ironed out most of the problems in producing noses of the required shapes and sizes with this new material.

Alumina is attractive for radome application for a number of reasons. Primarily, its most important attribute is a stable dielectric constant over a wide temperature range. Some trouble has been experienced with dielectric homogeneity, but research shows no insurmountable problem.



ALUMINA nose cones for *Sparrow III* missiles are mass-produced at Gladding, McBean & Co.

A second vital characteristic is resistance to thermal shock. Aerodynamic heating causes temperature changes of several thousand degrees within a few seconds. This tends to weaken the structural properties of the radome material. In addition, thermal gradients in the structure cause thermal stresses which can fracture the material. Alumina has successfully demonstrated its resistance to these shocks and stresses up to more than 4000°C.

- **Rain erosion**—In general, alumina is one of the most satisfactory refractory oxides for a wide variety of environments. It is unaffected by air, water vapor, vacuum or common atmospheric chemicals up to temperatures above 1700°C. It is much harder than glass and many metals, a factor extremely important due to the rain-erosion problem in high-speed missiles. Water droplets hit the surface of the radome like bullets with impact pressures high enough to fracture most materials.

The big problem with alumina radomes is in fabrication. Both Raytheon and Corning use the "slip-cast" method of forming. The nearly liquid alumina slip is cast in molds and, after hardening, is fired at high temperatures in much the same manner as conventional pottery. In the "green" stage, large castings have a tendency to slump, or deform, if not handled properly. Techniques have been perfected only recently to minimize this characteristic.

Research is aimed at producing a finished casting that needs no further work. This has not been successfully done to date, however. The rough casting must be machined to provide the critical wall thicknesses and smooth outside contour required. Due to its hardness, the alumina must be finished down with diamond tools. This process is one of the more critical operations and is expensive and time-consuming.

Gladding, McBean & Co., Los Angeles, has produced ceramic radomes for the *Sparrow III* by forming alumina on steel mandrels. (M/R, 3/16/59). Alumina, in the form of slurry, is sprayed on the steel forms and, after drying, subjected to pressures of over 30,000 psi to obtain a uniform density. The radome receives a preliminary firing and is then machined to the final thickness and contour. Final firing is at 3000°F. The company is presently working on a WADC contract for study phases and delivery of radomes for unspecified missiles.

The necessity for precision techniques is easily understood when a radome is considered as a lens that must be transparent to the outgoing and returning radar signals. It must not attenuate the signal nor bend the beam and yield false target information.

Basic optical laws apply and the slightest imperfection or varying thickness will produce undesirable refraction and aberration. Happily, due to the frequency (wavelength) of the radar signals and the scan pattern, the point of the nose—which would apparently present an optically impossible configuration—is not important.

Engineers working with alumina feel there is no practical limit to the size of domes that can be built. Corning has made alumina units as large as three feet in length and has bid on 12-foot units. Raytheon has produced radomes approximately four feet in length and 20 inches in diameter. Both companies feel that alumina domes can be mass-produced in quantity at reasonable cost.

Mercury Needs Based on Safety

NASA and capsule contractors pick laminated glass fiber and resin for heat shield, nickel cobalt for outside skin, titanium for inner vessel

by C. Paul Means

WASHINGTON—The materials to be used in the final *Mercury* capsule design that will take man on his first flight into space are laminated glass fiber and resin for the ablation heat shield, nickel cobalt for the outside skin, and titanium for the inner pressure vessel.

These materials were selected after extensive research conducted by the National Aeronautics and Space Administration at the Langley Research Center, by the *Mercury* capsule's prime contractor—**McDonnell Aircraft**—and by the **B. F. Goodrich Co.**, the **Cincinnati Testing Laboratories,** and **General Electric Co.**

Most important to the welfare of the astronaut is the heat shield, which must withstand temperatures of about 2600°F upon re-entry if he is to survive.

• **Tests satisfactory**—The laminated glass-resin ablation shield was picked because of its ability to withstand temperatures of 3000°F. One of this type made by B. F. Goodrich Co., worked perfectly recently when boosted 100 miles down the Atlantic Missile range by an *Atlas* booster.

During this test, the capsule re-entered the earth's atmosphere at an altitude of about 250,000 feet, traveling 14,000 miles an hour. The blunt shape of the heat shield plowing into the atmosphere slowed the vehicle to approximately 500 miles an hour.

Maximum temperatures on the outside skin of the shield reached about 3000°F during the critical minute or two of re-entry, and resisting air only a few inches ahead of the plunging capsule hit a temperature of about 10,000°F for a few seconds.

The laminated glass-resin ablation shield dissipated heat to the extent that temperatures stayed below 150°F within the titanium pressure vessel during the critical moments of re-entry. Throughout the rest of the trip, about 1400 miles down the Atlantic Missile Test Range, temperatures were kept between 80 and 100°F by an air conditioning system.

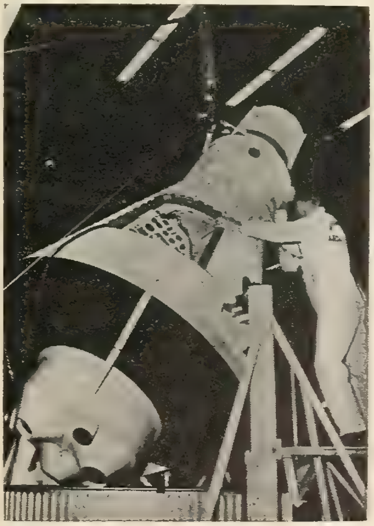
Detailed specifications for this heat shield and material were developed by the General Electric Co. The work of laminating the materials and forming the shield was done by B. F. Goodrich, and the shield was then sent back to GE for final machining and installation of sensing devices.

The favorable properties of the laminated glass-resin type of ablation heat shield include high liquid viscosity at high temperatures, low thermal conductivity, high energy of vaporization; and good thermal stress characteristic.

The plastic-like substance formed by the laminated glass and the epoxy rosin forms a liquid film rapidly, which being a poor conductor of heat, protects the shield against the initial thermal shock preventing sudden boil-off.

• **Structure material**—Behind the heat shield is the capsule's structural skin made out of nickel-cobalt. This material was picked for the capsule because of its strength, light weight, and ability to withstand heat.

Nickel-cobalt has been used with great success to solve the aerodynamic heating problem in high-speed airplanes and missiles. It has proved to be sufficient in the early capsule tests.



RE-ENTRY HEAT shield of abradable plastic by CTL is used in McDonnell's development of *Mercury* capsule.

Principal reason that titanium was picked for the inside pressure vessel is its ability—demonstrated in missilery—to withstand high temperatures without buckling.

Research into the problems of aerodynamic heating is difficult because it is almost impossible to simulate the extreme heat conditions of re-entry on the ground.

The Langley Research Center has been able to solve this problem by simulating the time and chordwise temperature variations with the use of radiant heat lamps. During tests, the radiator is lowered so that it is parallel to and only a few inches above the capsule. Structural temperatures of 2500°F can be produced on the model by this method.

For the space vehicles to follow after Project *Mercury*, NASA is working on two newer types of heat shields that withstand greater heat and allow the capsule to have a greater angle of re-entry.

One type under investigation uses an insulating material which is held in place on the load-carrying structure by a thin metallic outer skin. The outer skin is corrugated to provide a means for absorbing thermal expansion and to provide sufficient stiffness to prevent flutter. This design will be fabricated from a refractory metal such as molybdenum, niobium, or tungsten, and will reducing the temperature of the load carrying structure to 1200°F when the heat shield surface temperatures are 2500°F.

Another type of heat shield under investigation has an added heat-absorbing capacity in the form of water which is stored in a light absorbent material in channels formed by the stiffeners on the structure. This type of shield provides protection to the entire capsule structure and can hold the structure's temperature to that of boiling water. A more complicated structure design will be needed because of the difference in temperature between the shield and the structure.

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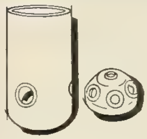

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MISSILE SUPPLIERS SPEAK

Here is a partial answer to the questions posed in the preceding section. Missiles and Rockets *asked leading materials suppliers to outline the state of technology, advances and limitations, and detail the applications to missile, rocket and space vehicle requirements of their special fields.*

Contributors also were asked to project the future trends of the technology and give their estimates of relative importance. Replies were received from 47 companies. Their statements are grouped in these categories: refractory metals; ceramics, insulation and coatings; plastics; tubing; metals; metalworking.

Refractory Metals

Machining Molybdenum Alloys

by George H. Waldeck

Cleveland—Vectoring nozzles which direct extremely hot and erosive solid rocket exhaust gases require utilization of new materials and introduction of new fabrication techniques.

The old concept of "high temperatures," such as 200°F to 1600°F, has given way to new working ranges of 1500°F to 5000°F. No engineer concerned with design or performance can disregard the inevitable conclusion that even higher temperatures—approaching 7000°F—will be standard factors with which to contend in the construction of future missile and rocket systems.

Of the refractory metals, molybdenum, tantalum, and tungsten maintain reasonable structural integrity at elevated temperatures. Molybdenum, with a melting point of 4760°F, is the most readily available of the three. Although rapidly and extensively eroded at high temperatures (a factor shared to varying degrees by all the refractory metals), molybdenum retains—for short duration–appreciable mechanical properties at temperatures approaching its melting point.

Experience in the successful fabrication of molybdenum nozzle components proves that cold molybdenum responds to most machining processes in much the same way as cast iron. But it is more brittle and offers considerably more resistance to drilling and cutting, with a resultant increase in tool attrition. Moderate heating of molybdenum stock improves machinability characteristics without impairing tool life. Correct tool geometry is essential but all machining can be carried out with minor refinements in existing conventional processes.

George H. Waldeck is Assistant Project Manager at the Systems Engineering Division of Cleveland Pneumatic Industries Inc.

Molybdenum's suitability quickly diminishes when the exhaust flame temperatures equal or exceed its melting point. Its useful temperature range can be extended somewhat by resorting to heavy "heat sink" designs; however, this would mean a prohibitive weight penalty. In a nozzle intended for use with the new high-performance grains where flame temperatures may exceed 6000°F, protective coatings might be a help. However, their reliability is still questionable. The next step is to look at tungsten or tungsten alloys.

- **Hot working**—Extensive experimentation has been carried out on a 50-50 W-Mo alloy to determine its machinability and to develop improved cutting techniques. Brittleness is accentuated to such an extent that cold processing results in extensive chipping and flaking. Tool attrition, in a cold process, is increased over the wear encountered in drilling pure molybdenum by at least 600%. By raising the temperature of the alloy during processing to 400°F-600°F, both drilling and cutting were vastly improved, and tool attrition and flaking and chipping were substantially reduced.

Since the temperatures necessary for proper handling of the alloys fall well below the critical temperature of recrystallization, repeated heating and cooling have no deleterious effect on the tensile strength or structural integrity of the material.

Experimentation indicates that comparable heating will permit successful machining of pure tungsten. Both tool material and geometry are very important in all cutting operations and major departures must be recognized in the cutting processes on both pure tungsten and its alloys.

There are several areas in which additional research is urgently needed before the refractory metals can be handled by either engineers or shop personnel in a wholly satisfactory manner. Three of these are: (1) Specifications for ultrasonic testing of the refractory metals. (2) Research in hot working and die forging processes at higher temperatures and in inert atmospheres. (3) Determination of mechanical and physical properties of the refractory metals in the region of 5000°F.

Moly Gains Point the Way

by Charles W. Brunstetter

Hawthorne, N.J.—The refractory metals are now being seriously considered for leading edge and other structural applications in advanced air and space vehicles. One reason is that re-entry frictional heating will subject the leading edge of a hypersonic vehicle to temperatures approaching 3000°F.

The refractory metals promise a solution to the temperature-strength-weight problem posed. Until now, however, these metals defied fabrication into sound structures, using conventional metal fabricating techniques. In addition, molybdenum was found susceptible to destructive oxidation at temperatures far below its maximum, desirable temperature limit.

In the past year **Astrometals Corp.** has developed a joining technique, on an experimental basis, for the successful fabrication of molybdenum. Information gained could conceivably lead to development of fabricating techniques for the other members of the group. In addition, molybdenum's susceptibility to high-temperature oxidation has been reduced through development of a protective coating.

Working with the National Aeronautics and Space Administration for the past year fabricating structural components from both coated and uncoated welded thin molybdenum sheet, we have developed resistance-welded sandwich structures with unusually high ductility and weld strength, which shows great promise.

Of the available refractory metals, the following appeared to have the most promise as structural material: molybdenum 0.5 Ti (**Universal Cyclops Steel Corp.**), niobium 10Ti. 10 Mo. (**E. I. duPont de Nemours & Co.**), and tungsten (**General Electric Co.**).

- **Coating stable**—We can now successfully fabricate structural components of 0.5 Ti molybdenum coated with **Chromalloy Corp.** W-2. They are formed at room temperatures and spot welded together. A special coating provides stability at temperatures up to 2800°F, compared to 2000°F formerly.

Sheet preparation and welding have yielded finished structures with good physicals. Longitudinal strengths of welded samples are approximately 80-90% of solid, extruded forms. In addition, the ductility of the resistance-welded molybdenum structure permits repeated flexing and straightening.

Molybdenum's well-known loss of ductility at sub-zero temperatures has also apparently been overcome. Plastic deformation can now be induced at below −100°F in treated material.

Evaluation of these structures on the basis of molybdenum's high thermal conductivity, low co-efficient of thermal expansion, high modulus of elasticity and high mechanical strength at elevated temperatures, promise a good, "hot" leading edge.

A structure with molybdenum as the skin and niobium as a supportive sub-structure seems to show promise, if anti-oxidation coating problems can be solved. A composite welded structure of this type can be made but the coating that gives the molybdenum good protection now embrittles the niobium.

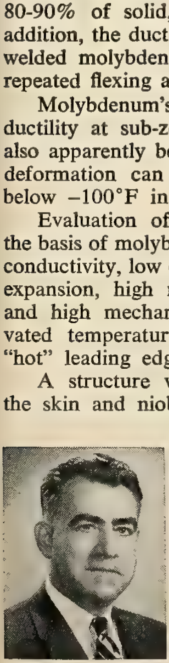
- **Up to 4200°**—The future of "refractory metals" appears extremely promising. Design engineers should soon be able to fabricate structures capable of withstanding temperatures as high as 4200°F for one hour.

Under a NASA contract, we are researching the potential of *all* refractory metals and their coatings. Emphasis is on fabrication of structures from thin sheet and their oxidation protection at high temperatures. Metals used in this investigation are molybdenum, niobium, tungsten, tantalum, beryllium (not classified as a refractory metal) and their alloys.

Tests will be made on methods of joining: resistance welding, electron-beam fusion, welding, riveting and ultrasonic welding. Work already started on molybdenum has resulted in good fusion welds, with good ductility, using the electron-beam welding techniques. Fabricated structures will then undergo protective coating evaluations for different environments. Structure types will include: primary load-carrying structures, radiation and heat shields, leading edges and nose cones for hypersonic vehicles.

Advances in refractory metal technology are assured by the R & D work being carried on by both NASA and the Wright Air Development Command, the molybdenum sheet-rolling program of the Bureau of Aeronautics, and the U.S. Navy-Universal Cyclops Steel Corp.'s "In-Fab" project. **Du Pont** is building a new, experimental refractory metal processing plant in Baltimore. General Electric Co. has a new type of molybdenum sheet (HD), which demonstrates a room-temperature ductility five times that of ordinary molybdenum. **Climax Molybdenum Co.** issued on Aug. 26, 1959, Specification Bulletin # CMX-FB-1, covering improved vacuum-arc-melting forging billets of molybdenum. Universal Cyclops is currently writing a specification for 0.5 Ti molybdenum sheet. **Bell Aircraft Co., Boeing Airplane Co., Pratt & Whitney Aircraft** and others are also working with refractory metals.

One observation is now justified: the super alloys of the jet engine age can not withstand the extreme temperatures anticipated in a manned hypersonic global plane's re-entry. The refractory metals provide us with the best current answer to these requirements, assuming that fabrication and service problems can be overcome. The good start, with molybdenum, points to the possibility that we will be able to utilize all of the refractories in the space program.



Charles W. Brunstetter is vice president of Astrometals Corp., formerly T. R. Finn & Co., of Hawthorne, N.J.

Tungsten Shapes Now on Hand

by John C. Redmond

PITTSBURGH—Heretofore virtually impossible to fabricate, pure tungsten and alloys such as tungsten-molybdenum and tungsten-tantalum are now available in hollow conical and cylindrical shapes, up to 8" diameter and 4" long. Billets 4½" diameter and 12" long are also available and can be forged into finished pieces.

By vacuum sintering techniques, we are currently producing tungsten metal of 99.9% purity with densities exceeding 90% of theoretical, which makes this material suitable for forging at 3400°-3500°F. Preliminary tests indicate that tungsten produced in this way has remarkable machinability characteristics at room temperature, after forging.

Equipment is now being designed and constructed to produce ingots of pure tungsten 10" in diameter and up to 18" long, weighing 900 pounds. By shaping before final sintering, special conical and cylindrical shapes are produced to relatively close tolerances, thereby greatly simplifying the forging operation for the finished end product.

Tungsten, twice as heavy as iron, has a melting point of 6170°F, the highest of the refractory metals. When weight is a critical factor, tungsten may be combined with other lighter metals of comparable metallurgy such as molybdenum, one-half the weight of tungsten, whose melting point is 4748°F. **Firth Sterling** is presently producing an alloy of 50% tungsten and 50% molybdenum with a melting point close to 5300°F in preformed shapes, requiring minimum forging.

Because of its excellent high-temperature properties, tungsten is a most desirable material for components in jet aircraft and engines, missiles and space vehicles. It also has important potential for radiation shielding, counterweights, gyro rotors, and many other commercial applications.

John C. Redmond is director of Powder Metals Research & Development for Firth Sterling Inc.

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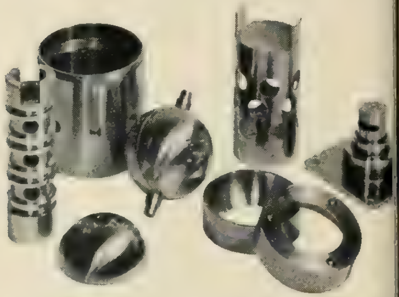

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Tantalum Easy To Fabricate

by Dr. James H. Gardner

CAMBRIDGE, MASS.—For all applications over 3000°F, tantalum is an extremely interesting alloy base because of its combination of high melting point (5430°F) and extreme ease of fabrication.

Tantalum-tungsten alloys are now being investigated for missile applications because of their remarkable high-temperature stress-rupture properties and because of their relatively high workability.

Applications for tantalum and tantalum-tungsten alloys in the missile field include exhaust nozzles, engine parts and other structural components subjected to very high temperatures. Possible skin and structure applications include leading edges and hot walls in boost-glide or other vehicles which must spend appreciable times in reentry and maintain their structural and aerodynamic properties. *Dyna-Soar*, for example, will require a reusable leading edge material able to withstand 2500° to 3000°.

Dr. James H. Gardner is General Manager of the Metals Division, National Research Corporation.

The prime disadvantage of both tantalum and tungsten is their high density (Ta—16.1; W—19.3). Strength-weight ratio at operating temperature is the limiting design criterion in most cases. On this basis, tantalum alloys become competitive or are preferred well below 3000°F. Tantalum-tungsten alloys are more oxidation-resistant than either element alone, but coatings will be needed in oxidizing atmospheres.

Ceramics, Insulation and Coatings

Alumina Kilns in Operation

by R. C. LeMay

DRESHER, PA.—Effective heat treating is vital in producing and testing missile and rocket components. Representative critical heat-treatments include firing of ceramic radomes, heat-treating of metal casings, and exposure of electrical components to accelerating temperatures and velocities to stimulate re-entry conditions.

Prominent among high-temperature materials being developed and employed in radomes and other critical missile parts is high-alumina ceramic. Its firing temperatures approach practical maximums for both air-gas flames and for the better known lining materials. But, alumina kilns have been built and are now operating satisfactorily, and still larger kilns will be constructed to turn out the larger missile components anticipated. Kilns of still higher temperature capability can now be produced by using oxy-fuels for combustion and stabilized zirconia linings.

R. C. LeMay is Manager, Contract Sales Research and Engineering, Selas Corp. of America.

For simultaneous overall heat treatment of metal casings (normalizing, hardening, tempering, annealing, etc.) the vertical drop-bottom furnace has become generally well established. As missile cases become progressively larger, simultaneous heat treatment becomes impractical. When such cases are generally free of attachments and of uniform cross-section, the heat treating requirement may well be filled by using a progressive treatment during horizontal travel through a relatively short "barrel" or "ring" type furnace with integral quench, such as we have successfully employed for continuous heat treatment of small and large pipe.

Of particular interest is the recent successful use, by a missiles components manufacturer, of an effective and much simplified device for inexpensively testing components through exposure to simulated re-entry conditions. The natural gas, enclosed combustion, "Superheat" jet-type burner has been scaled up and fitted with a wide range of "turndown" (from maximum to minimum burning rates); a high-velocity-high-temperature jet blast results, into which samples are advanced on a controlled moving "target" to match specified heat adsorption curves.

It has already been well demonstrated that as improved physical properties are required in materials by missile and rocket manufacturers, new formulations and heat treatments are developed to provide them.

Beryllium Oxide's Big Role

by Donald C. de Gruchy

NORTH BERGEN, N.J.—A remarkable combination of properties is creating a major role for beryllium oxide ceramics in three areas of missile and space vehicle progress: in missile borne and ground-support electronics; in nose-cone, nozzle, and wing structural applications; and in lightweight nuclear reactor design.

Beryllium oxide has a melting point of 4650°F, nearly 1000° above the melting point of aluminum oxide, and in ceramic shapes it retains useful

Donald C. de Gruchy is sales manager of the National Beryllia Corp.

tensile and compressive strength to unusually high temperatures. Tensile and compressive properties of beryllium oxide at normal temperatures are lower than those of aluminum oxide, and thorium oxide has a higher melting point. But, in the range of 1000° to 2000° no other known ceramic material possesses the average strength of beryllia.

The electrical insulating properties of high-purity beryllium oxide ceramics are comparable to those of aluminum oxide. Thermal conductivity is superior to that of silicon carbide and approaches that of brass. Thermal shock resistance is the best of all known ceramics.

Beryllium oxide is the second hardest known oxide—9 on the Mohs scale. The excellent abrasion resistance of high-fired beryllium oxide is of importance in many missile applications. Beryllium oxide is essentially unaffected by heavy nuclear radiation and is an excellent nuclear moderator—reflector material.

Beryllium oxide is highly transparent to microwave frequencies. It is free of outgassing, and thus is suitable as an envelope for, or component of, hermetically sealed equipment.

A major application is for heat dissipation from electronic assemblies, particularly where the ceramic can conduct enough heat away so that a blower is not required. Another electronic use is as a radar or microwave radiation window. The ceramic allows transmission of appropriate energy but seals against micrometeorites, pressure differential, moisture, etc

Two former limitations of beryllium oxide ceramics need no longer represent problems: safety of personnel has been a problem, since the inhaled dust of beryllium oxide is extremely toxic, but this ceramic is now produced with a hard-fired surface absolutely free of dust; limitations on beryllium oxide product configuration are removed by new production methods.

Size and cost are still limitations. However, increased use of beryllium oxides and of beryllium metal are reducing raw material cost, and advances in production know-how are reducing fabrication costs.

A much more varied range of beryllia-based materials is within sight. These include compounds of other oxides with beryllia, ceramo-metallic combinations, beryllium oxide foam, and beryllium oxide fibers.

Foam can be made; no applications have as yet appeared. Monocrystal and multi-crystal fibers have been produced in the laboratory and their properties are being investigated. Ceramo-metallic combinations among other potentials, offer the possibility of integral structures with properties deliberately varied from point to point within the structure.

Insulation Systems Foreseen

by E. F. Briggs

New York—Insulation materials now being used in the missile industry fall into the following basic categories: felted insulation; molded fibrous or porous insulation; fiber-reinforced plastic materials insulation.

Utilizing the most advanced techniques in the fabrication of thin foils of stainless steel, inconel, and titanium, a variety of products have been made available for protection of jet engine internal components including flexible insulated tubing, integrally insulated duct systems, and even complete encasement of engines

Similar applications are in common usage in missiles and rockets to protect surrounding structures and instruments from the heat of combustion of rocket engines.

Those applications involving minimum space requirements are best solved by utilizing newly developed Min-K, a molded insulation material whose conductivity (lower than that of still air) is the lowest of any formed insulation material.

Fiber-reinforced plastics are ideally suited for transient applications because of their high resistance to transient heat flow (low diffusivity) for moderate temperatures, excellent short-time resistance to elevated temperatures up to 10,000°F, and high heat absorption during ablation at extreme temperatures. Micro-Quartz has proven to be exceptionally successful as a reinforcement for reinforced plastic nose cones.

To protect temperature-sensitive instruments and permit the use of lightweight and economical metal structures, low-conductivity insulation is often required as a backup for low-diffusivity reinforced plastics. Thinner erosion-resistant or ablative reinforced plastic materials, backed up by low-conductivity insulating materials, provide the required protection with considerable weight savings.

E. F. Briggs is sales manager, aviation insulation products, for the Johns Manville Sales Corp.

To meet the demand for an integrated insulation structural material, we have just completed the development of Min-Klad Interlok, an integrated structural material combining the advantages of reinforced plastic with the low conductivity of Min-K. This is the first successful insulating system locking all components together in a single structure. Prototype applications include heat shields, component housing, instrument capsules, and erosion-resistant skin structures for missiles.

Just as the weapons system became the answer to the production of today's more complicated aircraft and missiles, we believe *insulating systems,* rather than insulating materials, will become a major factor in the design of future aircraft and missiles.

The missile insulating systems of the future will in all probability utilize the advantages inherent in both heat absorption and thermal shielding materials, irrespective of subsequent advances in either aerodynamic cooling or refractory structural materials.

Plasma Jet Aids in Coating

by Ben Lohrie

Culver City, Calif.—The softening, or melting, of materials and propelling them to a molten, or plastic state to a substrate, there to serve as a coating, is a common technique. However, usual processes begin to have a difficult time in the region of 4700° to 4800°F. Other material processes in and above this area normally are limited to sintering and hot pressing techniques.

More recently, a completely new and different electric device, operating on a constricted, gas stabilized arc principle, has been introduced. This is popularly referred to as a plasma-jet. The noble gas plasma offers pure heat at temperatures up to 30,000°F. This temperature not only exceeds the melting points, but also the boiling points of the elements. Inasmuch as the plasma is inert, no chemical change to the material transpires, as is possible in the combustion processes. Moreover, since the heated particles are being propelled at high velocity, the resultant impact assures improved porosity characteristics.

In the initial development stages of the Plasmatron (Giannini's trade name for the plasma-jet) it was evident that a very promising area of investigation was in the materials fabrication and processing realm.

Ben Lohrie is president of the Plasmakote Corp., an affiliate of Giannini Plasmadyne Corp.

Of the present uses, hyperthermal wind tunnels, ablation studies, cutting, and spraying, the latter holds the widest interest. Through this medium new worlds of material processing are now attainable. Spraying as performed by the plasma-jet can be classified into four groups: corrosion barriers; erosion barriers; heat barriers; self-supporting shapes. Within this classification it is possible to spray a very broad range of materials.

Considerable success can be expected with the oxides, including thoris and urania. Magnesia seems to be the exception and does not handle easily. Performing equally well are the borides, carbides, and to a limited degree, the nitrides. The stainless alloys are particularly easy to manage. Most of the elements and rare earths are manageable. Exceptions are aluminum and copper, whose melting points are too low for the prevailing temperatures.

Today plasma-sprayed materials are utilized in an impressive number of different applications for rockets and missiles: lining large combustion chambers; fabrication of high temperature-high velocity nozzles; fabrication of radomes and other structural components; hard facing the working parts of accessories and equipment; application of coatings to molybdenum alloy structures; employment of the rare earths such as niobium, iridium, and rhenium for classified applications.

Ceramic Coatings Beat Heat

by Roland J. Westerholm

WORCESTER, MASS.—Ceramic coatings are materials which ideally "do" nothing. They don't change state, they don't move and they have nothing to do with the theoretical operation of a rocket. However, this property of "doing nothing" is exactly the reason for their importance.

These coatings consist of hard adherent crystalline refractory oxides which protect the underlying material from high temperatures and abrasion. The coatings are both thermally insulating and electrically insulating. They can be applied to a variety of materials and are particularly adaptable to metals.

Roland J. Westerholm is product engineer in the Refractories Division of the Norton Co.

In the reaction motor field, coatings have these general properties and characteristics: very high melting point; extreme hardness; relative chemical inertness; good mechanical strength; applicability to a large range of sizes and shapes; high resistance to corrosion; dimensional stability; maintenance of close tolerance; low coefficient of expansion, and resistance to mild impact

From the above information alone, it would appear that the coatings are the answers to all sorts of high temperature problems, but there are some limitations. Ceramic materials are nonductile at room temperatures. Their compressive strengths are about 10 times greater than their tensile strengths. Coatings on concave surfaces such as the inside diameter of a tube will withstand many more cycles of heating and cooling than will the same coating on the outside of a tube or cylinder

At times, another limitation of the coatings is their slight permeability. In some cases, with time as a factor, corrosive agents will permeate the coatings and attack the metal, although such attack will be much slower than for uncoated metal.

One coating, made of alumina, will provide heat protection up to 3600°F. Another made of zirconia, will protect up to 4500°F. A third, of zirconium silicate, has less permeability than the former two, but will protect only to 3000°F.

Since they were first made available in 1955, Rokide coatings have been used in development work on the *Polaris, Hawk, Terrier, Sergeant, Recruit, Minuteman, Aerobee, Sparrow, Vanguard, Titan, Bomarc, Genie, Lacrosse* and *Explorer* rockets. These coatings are also in the *X-15* rocket aircraft.

Plastics

Re-entry Vehicles Use Ablation Plastics

by L. R. McCreight

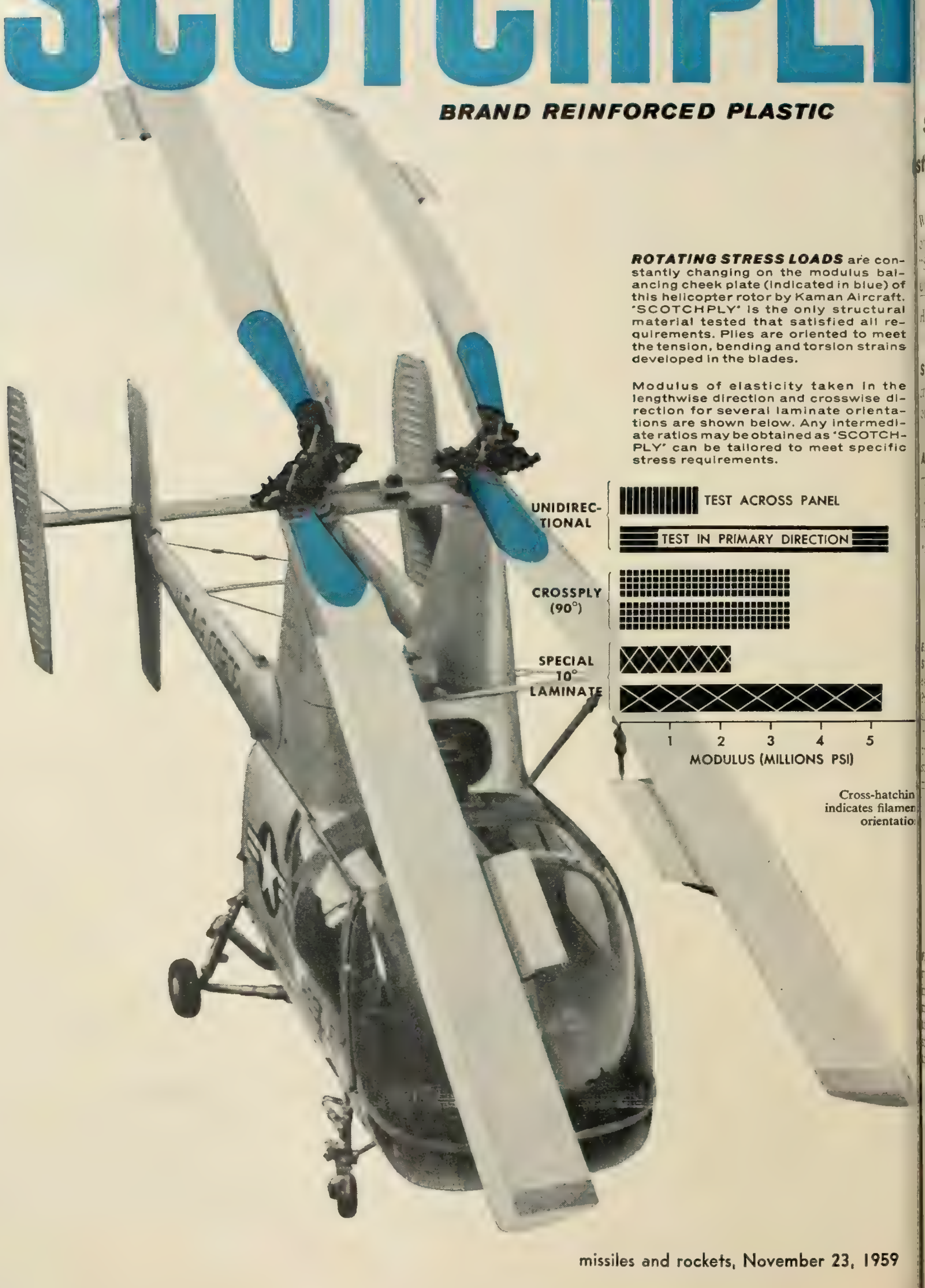
PHILADELPHIA—Reinforced plastics are the predominant material for protecting ballistic missile types of re-entry vehicles from the extremely high temperature environment.

In a few small areas such as the nose cap or possibly on the leading edges of fins for such re-entry vehicles, there is a desire for materials that resist volumetric erosion better than the current plastics.

In the case of manned re-entry vehicles or other vehicles where small re-entry angles and long re-entry times are specified, refractory materials that will reradiate the heat at some high equilibrium temperature appear competitive with the ablating plastics. In this category, we include niobium, tantalum, molybdenum, and tungsten and their alloys as well as graphite and graphite base materials.

SCOTCHPLY

BRAND REINFORCED PLASTIC



ROTATING STRESS LOADS are constantly changing on the modulus balancing cheek plate (indicated in blue) of this helicopter rotor by Kaman Aircraft. 'SCOTCHPLY' is the only structural material tested that satisfied all requirements. Plies are oriented to meet the tension, bending and torsion strains developed in the blades.

Modulus of elasticity taken in the lengthwise direction and crosswise direction for several laminate orientations are shown below. Any intermediate ratios may be obtained as 'SCOTCHPLY' can be tailored to meet specific stress requirements.

Cross-hatchin
indicates filamen
orientatio

TRENGTH-TO-WEIGHT RATIO TOPS ALL STRUCTURAL MATERIALS

*Strength/weight and other exclusive properties result from stomized orientation of continuous, non-woven glass filaments**

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Here are the superior properties that result:

★ ***UNMATCHED INDIVIDUAL PLY STRENGTH***—each ply consists of *continuous straight* filaments in parallel alignment, not crimped or woven.

★ ***HIGHEST DEGREE OF TAILORABILITY***—individual plies may be oriented to meet specific stress requirements; reinforcement (weight and bulk) is not wasted in directions or regions of low stress. This *degree* of tailorability is not possible with other reinforced plastics using woven cloth or short strand reinforcement.

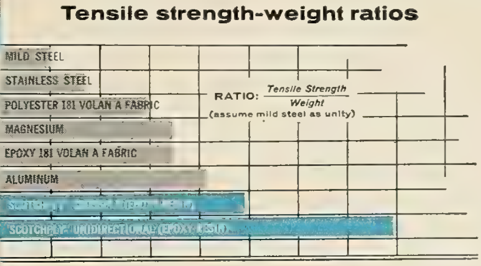
This duo of exclusive advantages combines to give "SCOTCHPLY" an unequalled strength-to-weight ratio and superior fatigue properties.

Sold in uncured rolls or sheets, "SCOTCHPLY" Reinforced Plastic is a moldable, laminated plastic consisting of a mechanically controlled ratio of resin to reinforcement*. Heat and low pressure in matched metal dies, vacuum or pressure-bag molding cure it into rigid form.

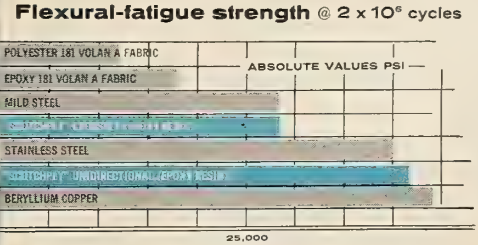
For complete information and technical service, write on your letterhead to Dept. XAC-129, Reinforced Plastics Division, 3M Co., 1210 University Ave., St. Paul 4, Minn.

**Other available filaments: nylon, asbestos and other ablation materials. Epoxy, phenolic and other resin systems are available.*

EXTREMELY HIGH TENSILE STRENGTH and light weight are ssential in this battery case by Prewitt Aircraft for a classified missile. By proper orientation of reinforcing filaments, "SCOTCHPLY" provides maximum strength where strength is needed to withstand tremendous acceleration loads.


Tensile strength-weight ratios
MILD STEEL
STAINLESS STEEL
POLYESTER 181 VOLAN A FABRIC
MAGNESIUM
EPOXY 181 VOLAN A FABRIC
ALUMINUM
"SCOTCHPLY" UNIDIRECTIONAL (EPOXY RESIN)
RATIO: Tensile Strength / Weight
(assume mild steel as unity)

LEXURAL FATIGUE failure of netal Fourdrinier springs resulted n costly breakdowns on this paper nachine manufactured by Rice Baron Corporation. Now Fourdrinier prings of "SCOTCHPLY"—tailored o the application—do the job.


Flexural-fatigue strength @ 2 x 10⁶ cycles
POLYESTER 181 VOLAN A FABRIC
EPOXY 181 VOLAN A FABRIC
MILD STEEL
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"SCOTCHPLY" UNIDIRECTIONAL (EPOXY RESIN)
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MINNESOTA MINING AND MANUFACTURING COMPANY
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Recently our laboratory developed a castable or low-pressure moldable ablation material at a small fraction of the cost of currently used thermal shield materials. Phenolics are the principal resin used for ablating thermal shields. Phenolics, however, are relatively difficult to fabricate in large pieces because the released water of condensation must be carried out slowly or maintained dispersed under pressure. While these materials have been successfully fabricated and used, development of more easily fabricated materials that would perform at least as well thermally is desirable.

• **Carbon surfaces**—We have accomplished this by studying the course of the degradation of plastics when exposed to high temperatures and concluding that, among other things, a carbonaceous surface layer is needed—a layer that must be of high quality, hard, and tenacious. Experiments with various additives to easily formed plastics, such as epoxies and polyesters, resulted in discovery of some that provide a hard, tight carbon layer when polyesters and epoxies were heated to extreme temperatures. These, as well as many other "pure" resins, do not normally give a carbonaceous surface when heated.

L. R. McCreight is Manager, Materials Studies, in the Aerosciences Laboratory, Missile and Space Vehicle Department, General Electric Co.

The next step was the study of other additives to provide other properties such as even lower thermal conductivity, lower thermal expansion, and a wide variety of physical properties, without any serious loss of ablation resistance.

While there are further developments to be made, we now have made clear, unfilled, cast materials to give properties as follows: thermal conductivity, 3 X 10^{-5} Btu-ft-sec-ft^{2}-°F; thermal diffusivity, 1.3 X 10^{-6} ft^{2}-sec.; heat of ablation, 5400-12,500 Btu-lb. depending on test facility (eg. air and water stabilized arcs, rocket motors); ultimate tensile, 3500 to 10,000 psi; modulus of elasticity in tension, 30,000 to 600,000 psi; elongation, 1 to 12%.

These resins can also be filled or reinforced to give other thermal and physical properties comparable with other widely known reinforced plastics.

More and Varied Uses Seen

by John H. Lux

WILMINGTON, DEL.—Plastics have made possible operating temperatures much higher than those possible in metals. Propellant burning temperatures of up to 6000°F are common in plastic blast tubes, nozzles, and exit cones. At this time they are available in any size up to 12 feet in diameter on a production basis.

Nose cones used on re-entry vehicles are subjected to temperatures up to 20,000°F. Plastic re-entry vehicles have been recovered. Here again, there is no limit to the size that can be manufactured.

Filament-wound motor cases give the highest possible strength-to-weight ratio and will enable large plastic motors to function with a much higher mass ratio. Future propellant grains may be cast, X-rayed, and then have the plastic motor case built around them rather than in the opposite sequence as is done now.

New high-pressure equipment results in higher temperature and higher ablation resistance. We have, for example, 1500 and 2000-ton presses with over 12 feet of daylight. Large scale equipment formerly characteristic of only metals fabrication is now in our plants—for example, our giant lathe with 36-foot bed and 12-foot swing.

Two 14-foot autoclaves, 12 feet in diameter, enable large parts to be pressure molded with practically no mold cost. Large 80-inch boring mills do precision turning of nose cones and exit cones to tolerances closer than those now common for metals.

Another major breakthrough in the field of ablation resistance has been the use of edge-wound or edge-oriented plastics. We have process equipment to manufacture mechanically wound, reinforced tape, at any angle from 0° to 90° from a longitudinal axis.

In a nozzle made using **Haveg** Planeton IV—edge orientation followed by pressure molding—ablation rates were about 1/20th of those normally achieved with molded plastic parts, and, in most instances of large-size nozzles, ablation rates were lower than those of graphite.

Future thinking certainly leads us to believe that a high proportion of the materials for construction of the new rockets, missiles, and space vehicles will be plastic. This will include nose cones, motor cases, nozzles, and exit cones.

We can look forward to huge liquid-fueled rockets that will use plastic insulation, instead of cooling the motor by fluid circulation. This would decrease total weight and provide increased reliability.

John H. Lux is president of the Haveg Industries, Inc., Wilmington, Delaware.

New Idea for Thermal Barrier

by J. C. Siegle and P. H. Settlage

WILMINGTON, DEL.—To cope with the excessive thermal energy generated at hypersonic speeds, a thermal barrier is required.

The union of a plastic to a metal having good mechanical properties is a new and exciting concept for use as a thermal barrier. At temperatures associated with aerodynamic heating, the plastic layer will decompose rapidly with absorption of considerable quantities of heat, providing protection for the metal substrate. Generation and diffusion of large quantities of gaseous decomposition products into the boundary layer are also advantageous; they will interfere with the convective transfer of heat to the surface, increasing the utility of the plastics as thermal barriers.

Of the large number of plastics available in industry today, the "Teflon" TFE-fluorocarbon polymers, which have an unusual combination of physical and thermal properties, are particularly suited for use as thermal barriers. In addition, the thermal and thermodynamic properties and kinetics of thermal decomposition are available and can be adopted to calculations pertaining to their performance.

J. C. Siegle and P. H. Settlage are in the Polychemicals Department of E. I. du Pont de Nemours & Co.

• **All-gaseous products**—The "Teflon" TFE-fluorocarbon resins are particularly suited for ablative application since they are converted upon pyrolysis entirely to gaseous products. Injection of these products into the boundary layer can contribute to additional heat absorption through mass transfer. The major product of decomposition is the monomer tetrafluoroethylene. The composition of the gaseous decomposition products remains constant over the entire range of conversion.

Calculations of the extent of thermal decomposition are simplified since the reaction follows first-order kinetics.

When the temperature dependence of the rate constant in which the logarithm of the rate constant is plotted versus the reciprocal of the absolute temperature, a steep slope results. This indicates a sharp change in the rate of decomposition with temperature which appears to be a desirable attribute of the "Teflon" TFE-fluorocarbon polymers for use as thermal barriers.

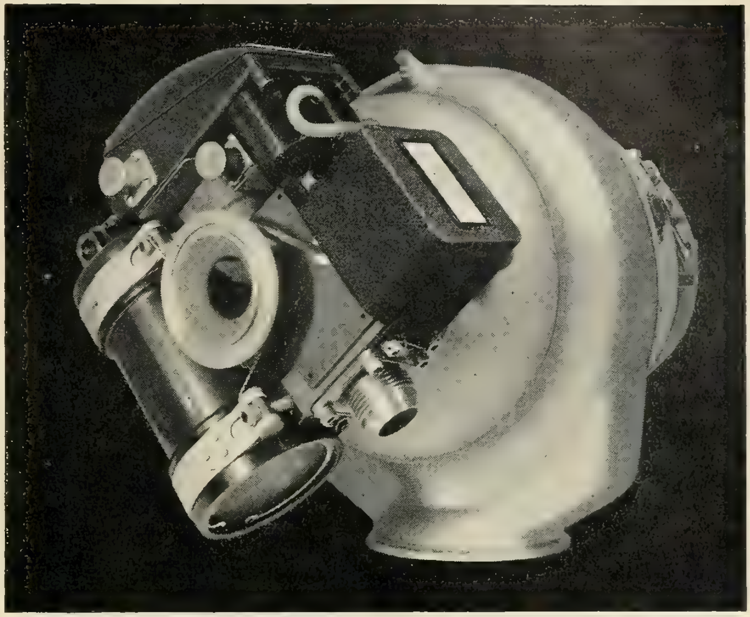
The slow rate of thermal conduction through coatings of TFE-fluorocarbon resins is important in their use as thermal barriers. As a result, the incident heat energy is almost completely consumed by thermal decomposition of the external surfaces.

Retention of mechanical properties at elevated temperatures is extremely important to the performance of plastic materials as thermal barriers. The "Teflon" TFE-fluorocarbon resins are unusual among plastic materials since fabricated sections do not melt flow, crack, spall or completely lose their mechanical properties, even at temperatures far in excess of their melting point of 327°C (620°F). This is confirmed in experiments both in a solar furnace and a plasma jet.

In summary, the union of plastics with metal substrates for use on aerodynamic surfaces at high velocities offers a new and unique approach to the problem of heat dissipation. Although many plastic materials are available, coatings of "Teflon" TFE-fluorocarbon resins can be utilized advantageously as thermal barriers. Availability of thermal and thermodynamic data for "Teflon" TFE resins allows accurate calculation of the thicknesses required to provide thermal protection.

Utilization of minimum quantities of plastics to meet specific thermal requirements offers advantages in weight savings and power requirements of propulsion systems. And the excellent electrical properties of the "Teflon" TFE-fluorocarbon resins extend their utility to other applications in which thermal protection is not the dominating criterion of performance.

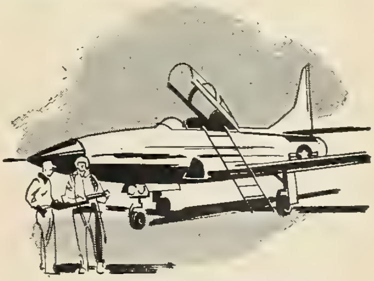
NEW BENDIX® FUEL-AIR COMBUSTION UNIT DOUBLES AS AIR-TURBINE STARTER!



Here's the newest state of the art in starter design—Bendix Utica Type 36E73-2A. It takes a mixture of compressed air and aircraft fuel and provides long-life starting capabilities for engines with high-energy starting requirements. Then, a simple movement of the selector switch allows air-turbine starting from the same unit by cross-bleeding compressed air from another engine to the turbine section of the starter.

A self-contained starting system, independent of outside support equipment, the new Type 36E73-2A also provides a two-start capability for each starter application—one start immediately following the other before a cooling period must be applied. The starter automatically locks in the start cycle, and automatically disengages from the engine after starting.

A new brochure outlines all the facts on the new Type 36E73-2A starter. Write Bendix Utica—leader in the field of jet-engine starters—for your copy.



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Aid from Silicone Rubbers

by Robert Treat Jr.

PHILADELPHIA—Only two years after their introduction, RTV (room temperature vulcanizing) silicone rubber compounds continue to extend the usefulness of conventional heat-curing silicone rubbers by eliminating the need for heat or pressure in the curing systems.

RTV provides excellent abilities for: protection of today's electronic and electrical assemblies; encapsulating electronic components, such as aircraft transformers; and protecting delicate electronic components from the effects of shrinkage when encapsulated in epoxies.

Robert Treat Jr. is a rubber specialist in the Silicone Products Department, General Electric Co.

RTV silicone rubber offers a number of unique characteristics to offset the disadvantages of both rigid and conventional mold materials, thereby enabling prototype parts to be cast more easily, accurately and economically than ever before. Some of the primary characteristics of RTV that contribute to its usefulness as a mold material are: low shrinkage, elimination of parting agent, superior surface and fine detail, high temperature resistance, and quantity model production from a single mold.

Missile applications for RTV include bonding gages while loading LOX; ablative compounds for nose cones and re-entry vehicles; binding for solid propellants; and insulator for propellent grains.

Demand Grows for Astrolite

by W. E. Benke

LOS ANGELES—Astrolite, a combination of virtually pure vitreous silica fibers (known as Refrasil) and a resin binder, is in tremendous demand for extremely high-temperature insulation and high gas velocity ablation applications on missiles.

Temperatures where Astrolite is used satisfactorily range from 5000-6000°F to several times this figure. It has proven itself an excellent material in a large number of missiles for nose cones and rocket engine components, such as nozzles and blast tubes.

Why does this material work? Although the high-temperature resin binder carbonizes at approximately 500 degrees F, the Refrasil has a melting point above 3000°F. Upon melting, the viscosity of the Refrasil is extremely high, preventing it from being easily blown away. Also, the melted Refrasil vaporizes, which tends to cool the surface of the material.

W. E. Benke is vice president for sales engineering of the H. I. Thompson Fiber Glass Co.

As with all materials, the maximum performance of Astrolite fabricated parts for any particular service requirement can be achieved only by proper design considerations. For example, fiber orientation of the reinforcement is important to the success of most applications.

All of the regular methods of molding fiber glass phenolic parts are applicable to Astrolite—vacuum bagging, autoclaving and press molding. Densities obtainable range from 80 to 110 pounds per cubic foot.

Machining of Astrolite can be done on post-cured parts as well as on parts which have not been post-cured. Our experience indicates that machining can best be accomplished by use of diamond-tipped bits, saws, and grinding wheels.

Old Items Find Space Uses

by F. William Jahns Jr.

NEWARK, DEL.—Non-metallic shapes and structures are being used on an increasing scale for missile applications, including some of the oldest established items such as vulcanized fiber and conventional phenolic laminates.

Space Age products cover vulcanized fiber, a wide range of laminates, rods, tubes, fabricated parts, molded parts, post-formed items, flexible insulation, and laminates for printed circuits.

Raw materials used include different types of paper woven and non-woven fabrics, and mica. Woven fabrics are made from cotton, nylon, asbestos and glass. Special constructions based on glass mat and felted asbestos are also used. The resins used are conventional phenolics, special types of heat resistant phenolics, melamine, epoxy, silicone, polyester, and **duPont** Teflon.

One of the most active areas of interest for our high-temperature materials is in connection with solid propellant engines. In a typical use, the plastic is used as thermal insulation and is exposed for a short period to temperatures in the range of 5500°F.

F. William Jahns, Jr. is in the Technical Service Department of the Continental Diamond Fibre Corp., a subsidiary of the Budd Company.

Production parts are being supplied for exit cones and also for the quality control tests and improvement of the solid propellant.

Some of the properties that have been responsible for the adoption of plastics for high temperature use in missile applications are:

Retention of a large percentage of mechanical strength after exposure to elevated temperatures and when tested at high temperatures; good dimensional stability; thermal properties (low thermal conductivity); high strength-to-weight ratio; resistance to moisture; resistance to hot gas erosion and ability to stand direct exposure to burning rocket propellants; longer burn-through time than metals.

Typical future trends follow: flame retardancy; fungus resistance; higher impact strength; paper base epoxy laminates; and composite structures.

Areas requiring further investigation include: fatigue properties; exposure to nuclear radiation; effect of cryogenic temperatures; development of higher melting points; high-temperature adhesives; weight reduction; correlation of the laboratory test methods compared to the service conditions; effect of post-cure on ablation; extremely high noise level; high-temperature retention of bond strength of metal clad laminates; infrared detection characteristics; effect of vibration and severe environmental conditions; and thermal conductivity in the temperatures range of 1000°F to 5000°F.

Filament Winding for Cases

by Richard E. Young

ROCKY HILL, N.J.—Initial research in the application of filament-wound structures to missiles followed closely on the commercial availability of continuous drawn glass fibers and 100% reactive thermo-setting resins.

Ultimate strengths in hoop have been demonstrated in pressure cylinders greater than 135,000 psi, yielding a strength-weight ratio of slightly over 1.8 million inches. As all primary load is carried by the glass fibers, the resulting tensile stress on the glass fibers averages 300,000 psi.

Early research was devoted to development of design and fabrication techniques for simple cylinders; later work has resulted in cylindrical structures with essentially closed ends. Recent developments include rocket cases with cutouts for nozzle and terminator ports, cases with integrally-formed nozzles, and cases with integrally-formed skirts.

Principles to be followed in designing cases to be formed by the process are not yet broadly understood. As knowledge of these structures was gained from experience, it became evident that they should be regarded as resin-less nettings of high-strength filaments operating in tension only. In properly designed structures, the entire netting system should be in complete balance, with no stress evident except tension in the fibers. In practice, however, there is compression across the fibers resulting from internal pressure communicated from layer to layer.

To form rocket cases with closed ends, two winding systems are combined in the cylindrical portion of the vessel: one oriented in a low helix angle that is nearly axial, the other in a circular direction. The low-angle helical filaments can be passed over an end shape, leaving only a small polar opening and returning to a helical path on the opposite side of the vessel. The term "ovaloid" has been applied to the special end profile which is the natural shape for the corresponding system of terminal windings. With the entire structure designed with all fibers continuous and in tension only, the system is always geometrically similar to the unloaded unit, for thin-shelled structures eliminating secondary bending.

Richard E. Young is director of the Young Development Division. Hercules Powder Division.

In theory, it is exceedingly undesirable to cut openings in pressure vessels such as rocket cases. It has proven feasible, however to provide multiple openings by special techniques. Openings, both in cylindrical and ovaloid surfaces, have been used in cases having from zero to 1000 psi internal pressure. In the same way, much has been learned in accommodating special requirements for mechanical attachment of closures and other devices.

As requirements in the missile field have advanced, the size and complexity of filament-wound cases have increased. Where initially only small tubes were used, complete chambers of considerable girth are now fabricated regularly.

Versatile Laminated Plastics

by Dr. Carlisle M. Thacker

NORRISTOWN, PA.—Laminated plastics—also known as reinforced plastics—are the surprise material of missile-rocket technology. What makes them uniquely suitable for many rocket-missile applications is their ability to stand up under extremely high temperatures for short periods of time. Metals quickly heat through and lose their strength or even melt; laminated plastics, on the other hand, have low heat conductivity so that heat damage is confined to the surface.

Laminated plastics have other properties that contribute to their usefulness in rocket applications. One is their high strength-to-weight ratio. Some grades of laminates are as strong as metals and they retain their strength at extremely high temperatures. Because the destructive effect of heat is limited to the surface they retain more of their original geometry and hence more strength.

Laminated plastics have high resistance to thermal shock and are lighter. They are also easy to fabricate. They machine more easily than metals and they may be molded into a wide variety of shapes.

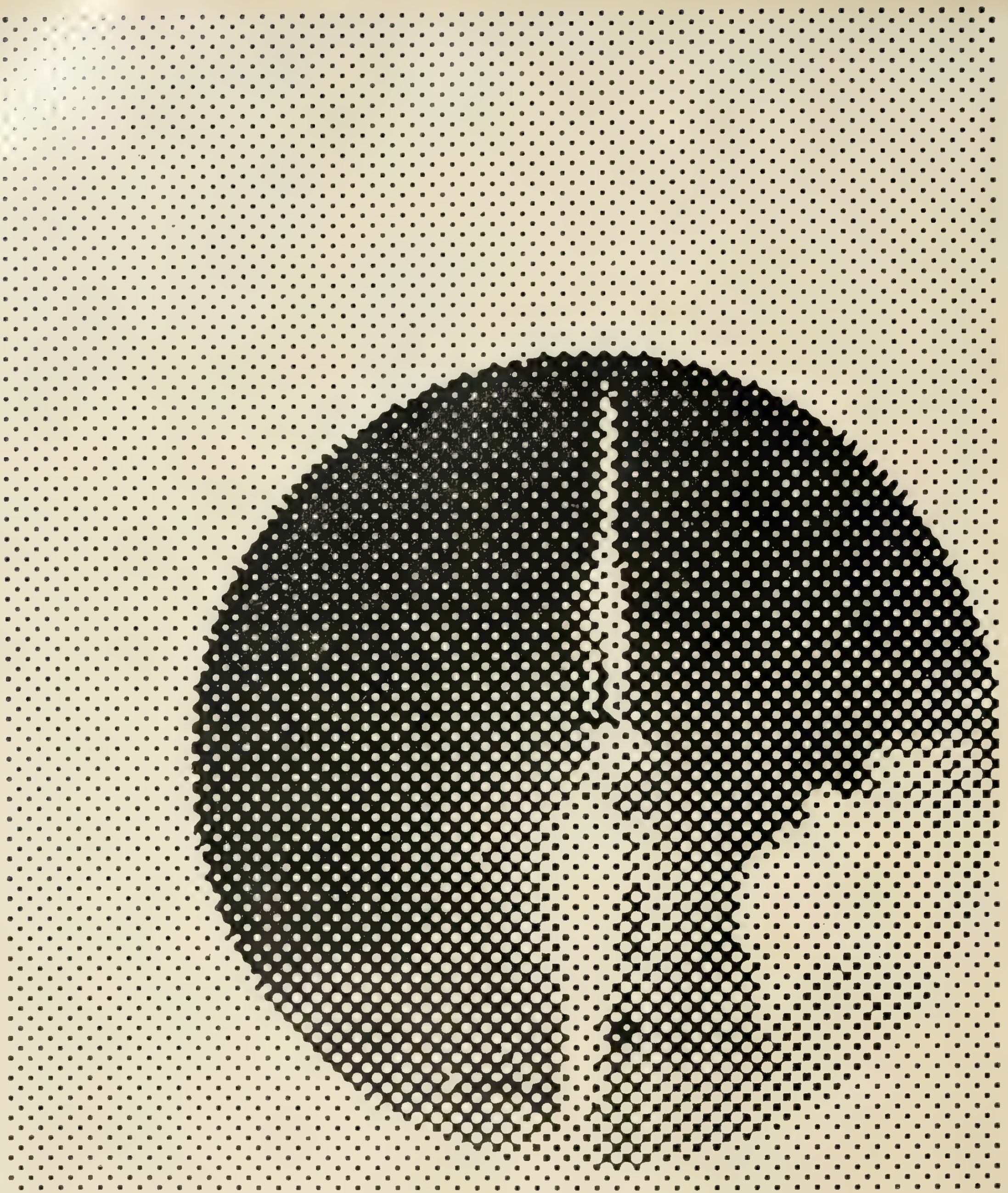
Already laminates are supplied for use in nose cones, exit cones, blast tubes, insulators, insert bulkheads, jet vanes, motor cases, rupture disks and throats—with more use reported almost daily.

A factor that has limited to some degrees the use of laminated plastics in missiles and rockets is their published property values—usually the standards of the National Electrical Manufacturers Association (NEMA standards). Since these standards are primarily for electrical applications where strength is secondary, the published data are usually below the actual tensile strengths of the materials.

Dr. Carlisle M. Thacker is Technical Director of the Taylor Fibre Company.

Wider use of laminated plastics may also be expected with continued progress in combining them with metal. Because they combine the strength of metal with the superior insulating properties of laminated plastics, these composite materials hold great promise in rocketry engineering.

One of the most pressing needs is to develop a wider variety of simple and inexpensive laboratory methods and equipment for research and for testing laminates for particular properties required in rockets and missiles. The availability of simplified, *inexpensive* testing equipment will accomplish two important goals: (1) permit development and adoption on an industry-wide basis of laminated plastics specifications tailored to the rocket and missile field; and (2) expedite research by savings in time and cost in evaluating new developments.



There are 7,500 dots shown here.
This is the number of engineers in the
eight divisions of Martin. And 40 percent
of these—the 3,000 dots in the circle—
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It is this specialized
capability that enables Martin to develop
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Example: A Martin electronic
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Activation, Baltimore, Cocoa,
Denver, Nuclear, Orlando, RIAS, and Space Flight.

Phenolics Gain In Missile Uses

by Minert E. Hull

North Tonawanda, N.Y.—Use of phenolic plastics in missiles and rockets has opened a new field of technology.

This family of plastics has given outstanding results in nose cones and rocket motor insulation, primarily due to their inherent properties. Another reason is their long-time use with a well developed technology, particularly in replacing metal with plastic parts.

The thermosetting phenolic materials are designed for molding in matched metal dies at pressures of 500-5000 psi at 250-350°F.

Selected Durez heat-resistant phenolic resins modified with minerals, finely divided or as reinforcing fibers, have shown excellent insulation and erosion resistance in solid propellant rocket motor exhaust nozzles and internal parts. Two of these materials are Durez 16771, glass roving impregnated with phenolic, and Durez 19387, a quartz fiber-filled phenolic material in free-flowing granular form.

Exit nozzles of these materials were fired in a high-impulse **Thiokol Chemical Corporation** solid-propellant motor and exposed to 5000°F gas velocity of Mach 3.0 for 40 seconds. Durez 16771 eroded at a rate of 4-5 mils per second, while 19387 showed virtually no erosion. Both materials showed about ⅛" depth of char. A ½" thick phenolic-asbestos insulation was completely destroyed under these conditions.

These materials are intended primarily for insulation of metal components. They would have specialized limited use for pressure vessel applications and would require reinforcement by metal or a laminated plastic structure.

To obtain optimum strength and erosion resistance in a rocket or missile, uniform density of a molded part is imperative. High-density plastic parts are best produced in matched metal dies by the compression molding method. Some reinforced plastic materials do not flow readily in thin sections due to their bulky fiber fillers.

Minert E. Hull is supervisor, molding compound research and development, for the Durez Plastics Division of Hooker Chemical Corp.

missile suppliers speak: Plastics

Mold design and molding techniques determine success or failure in the application of such materials. Thus the plastic raw material supplier, the custom molder, and the rocket design engineer must cooperate very closely on mold design.

Durez 16771 is unique in being the only known commercial phenolic molding material with zero molded shrinkage. Molds can be built with no draft or taper and finished parts molded directly to size, making it possible to mold true cylinders, blast tubes and other missile parts to close tolerances.

To obtain high quality plastic parts, rocket engineers must find an experienced custom molder with suitable equipment and a sound engineering staff, perhaps difficult since only a few concerns will invest the money and effort to make a few precision missile parts on a research basis without reasonable assurance of a production run.

Super-phenolics in missiles hold great promise. Their excellent strength-to-weight ratio, insulation value and erosion resistance have been established. Their use should grow as the design engineers gain knowledge and confidence in the technology of their use in missile systems.

Strength Levels To Double

by **Howard Meinke**

COPIAGUE, N.Y.—The field of non-metallic structures for spaceflight and missiles is still in its infancy. Even so, composite structures of plastic in combination with high-tensile glass, quartz, ceramics, etc., have already surpassed the best metallic structures for many high-strength, high-temperature applications.

One of our latest developments has achieved a workable hoop tensile strength in the pressure chamber of a large solid rocket motor case (test motor, U.S. Naval Propellant Plant) of 200,000 psi. This is achieved by tape-winding new high-modulus Houze glass with epoxy resins. The bulkheads are tape layups, match die-molded. These are attached to the cylindrical body by a specially prepared proprietary joint. Final wraps are then applied. Considering the density of this configuration (0.070), compared with that of steel (0.283), strength-to-weight ratios for the non-metallic structure are superior by a factor of four-to-one.

The future of this technology depends jointly on the ability of glass filament developers to produce still-higher-strength filaments, tapes, mats, etc., and on the ability of the composite-structure development engineer to utilize it to its utmost effectiveness. There is no reason to assume that current strength levels of non-metallic structures cannot be doubled within a reasonable period.

Howard Meinke is chief engineer of the Plastics Branch, Fairchild Engine & Airplane Corp.

Tubing

Fiber Glass Toughened Teflon

by **Titeflex Inc.**

SPRINGFIELD, MASS.—Flexible hose is necessary in every liquid-propelled rocket engine. The *Thor, Jupiter, Redstone* and *Atlas* missiles make wide use of flex hose of various kinds during testing and in operation. It is also used in the *X-15* rocket aircraft.

Thermal expansion, engine vibrations and the necessity to thread pipe around obstacles make flex hose necessary for delivering gas and liquid fuel at varying temperatures.

We have just introduced a hose capable of operation between —65 and 400°F, with a bend radius about three times its inside diameter, which may run as much as 2″. The hose, called Springfield 400 is made by braiding stainless steel wire about a hose made of **duPont** Teflon and fiber glass. Until now, there had been no Teflon hose that retained flexibility when it exceeded 1″ in outside diameter.

Springfield 400, unlike most Teflon hose, does not have an extruded inner core. Instead, unsintered Teflon tape and Teflon-impregnated fiber glass tape are wrapped and fed into a die that forms the laminated structure into helical convolutions. The inner core is thus a convoluted Teflon core reinforced with fiber glass, offering maximum flexibility as well as outstanding resistance to corrosive fluids.

Swage Fitted Teflon Tubes

by **R. C. Ramé**

ROSELAND, N. J.—Flexible plumbing used in the stratosphere and beyond must be of material that is chemically inert over a wide range of temperatures, is non-contaminating, has limitless life, and is light in weight.

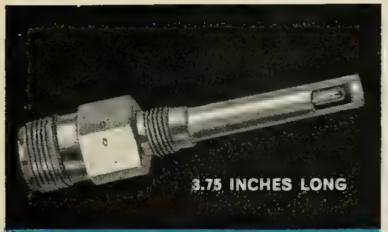
Teflon, the **du Pont** fluorocarbon resin, properly fabricated, is the only flexible hose material that meets all of these basic requirements. The reliability required for use in jet aircraft and hydraulic and fuel lines in missiles and rockets is dependent upon the fabricator's techniques and experience.

No one characteristic of a fluorocarbon hose plumbing system can be considered of primary importance to the success of its missile application—each unique quality has a relationship with the next. It must be completely non-contaminating; withstand severe vibration and g forces; be capable of intricate fittings in a highly restricted space; be chemically inert; be lightweight, have high strength, and have a long shelf life. Fluroflex-T hose assemblies with swaged fittings and made of Teflon meet all these rigid requirements.

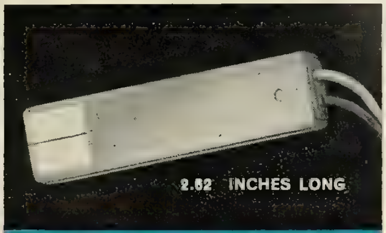
For the future our research department has developed and is testing specially constructed lines for almost indefinite use at much higher temperatures than the 623° to-650°F now considered the limit of 100% reliability.

R. C. Ramé is Manager, Field Engineering of the Fluorocarbons Division, Resistoflex Corporation.

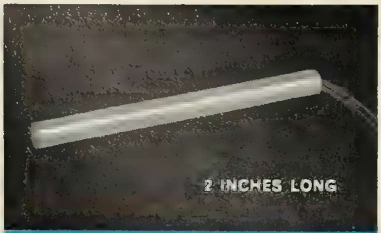
THIS HIGHLY ACCURATE TEMPERATURE CONTROL



Duct type thermostat. For duct gas or fluid sensing applications. Employs the latest in unique stainless steel brazing techniques for high temperature and high pressure applications. (This type thermostat being used by Douglas Aircraft Company for ground support cooling equipment—in conjunction with VĀP-AIR panel for Hi and Lo temperature warning system—for the Thor Missile.)



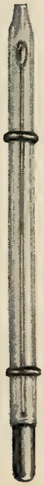
Surface type thermostat. For surface "area contact" temperature sensing. Employs the latest in high heat resistant materials for adequate ambient temperature isolation and excellent shock and vibration characteristics. (Used by Northrop Corporation for controlling critical mass temperature in a sub-miniature accelerometer.)



Well type thermostat. Cylindrical shape—suitable for "blind" well applications for sensing case temperatures. (This type thermostat being used by Sperry Gyroscope Company to sense and control accelerometer housing temperature.)

CAN BE APPLIED TO YOUR MISSILES, AIRCRAFT OR ELECTRONICS PROBLEMS WITH

Vāp-Air merc thermostats



These VAP-AIR thermostats provide the same reliability and optimized design as the individually designed thermostats incorporated in complete VĀP-AIR systems, used widely in missiles, aircraft, and electronic gear.

Thermostats tested at 100G shock; vibration 10G's to 2,000 cycles per second without malfunction. Tests have been run a total of over 2 million cycles, and calibration remained within $\frac{1}{10}$ of 1° of original setting.

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Provides all the information necessary to determine the right thermostat for the job. You order out of the bulletin; VĀP-AIR ships without delay.

Bring us your temperature control systems problems. There is a wide variety of other VĀP-AIR electronic controls, valves and actuators, both mechanical and electro-pneumatic, to meet your requirements over a wide range of response time.

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Materials Research Called Inadequate

by John N. Dick

WASHINGTON—Availability of necessary materials for spacecraft will depend largely on the emphasis placed on materials research.

We are still spending dollars on weapons and space systems sophistications, while spending mills for the materials research and development required to make them in quantity and put them into usable configuration. Unless this point is recognized we are likely to create a configuration of fantasy, one that cannot be built except at excessive cost.

New and more complex processes will require better and more expensive equipment. In some cases, automation and numerical control must be adopted on a wide scale. Handling and testing equipment must be improved and new standards of quality control and data evaluation must be developed.

So that the metals of a decade hence, or even five years from now, will be capable of meeting the greater demands outlined here, we should begin today to give greater emphasis to materials research through the production stages. Also, we should give greater metallurgical guidance at each level of systems development from the predesigner, to the design engineer, to the fabrication developer and finally to the production unit.

A good start in helping to solve the problem would be for civilian and military agencies to raise men in their organizations responsible for materials guidance to greater prominence.

Our spending of monies for advanced material development for the long haul—research on materials to be used 20 years from today—seems to be improving. Where there is a need for more research assistance is in the more immediate area on development of volume of materials that will be used five years from today.

Col. John N. Dick (USAF, Ret.) is the Washington district manager of the Allegheny Ludlum Steel Corporation.

While the basic research metallurgist has come up with a new alloy and in his laboratory has made ten pounds of the material, he still doesn't know how to make ten tons of it. There is need here for some research to move this production knowledge faster than industry today is capable of doing by itself.

It is one thing to create a new metal, an alloy or other type material, it is another to produce it in volume. Here then is the area wherein assistance is required and a unified approach is essential—not only in financial assistance but also in the areas of supervisory guidance, improved administration and raising the status of the materials engineer or production metallurgist to a person with equal authority on the team.

Republic Reduces Impurities

by J. A. Rinebolt

MASSILON, OHIO—The rapid advancement in missile and rocket design has increased the need for metals that have high strength per unit weight at flight temperatures.

Such factors as transverse ductility and cleanliness are vital. Fatigue strength is closely related to these characteristics. Therefore, considerable attention has been focused on the benefits derived by vacuum-melting steels. Steels being melted range from low-alloy steels to high-temperature steels such as A-286.

Ultra-high strength, high-temperature alloys are melted in our new 30″, 24″, and 18″ consumable vacuum arc melting furnaces. Ingots weighing between 4000 and 16,000 lbs. are being produced at pressures of less than 20 microns. In this process, segregation and center porosity are minimized. The non-metallic inclusions are reduced in number and size, primarily because of the absence of contaminating effects of atmosphere, furnace and ladle lining, slags, etc. Hydrogen, oxygen, and nitrogen content are materially reduced, making the steel less susceptible to flaking after forging.

Alloys melted in these furnaces include AISI 4340, M 300, and a special grade containing .45% carbon, ½% nickel, 1% chromium, and 1% molybdenum.

J. A. Rinebolt is the Supervisor of Alloy Research and Development at Republic Steel Corp.

Specifications for missiles and rockets requiring 15% average and 10% minimum reduction of area at these high-strength levels are successfully met by the alloys produced by the vacuum-arc process. At these levels, the strength-to-weight ratio equals or exceeds that of other materials used in aircraft and missile applications.

Vacuum-consumable, arc-melted steels have helped meet the demand for premium quality materials for rocket and missile applications. In the future, alloys such as the 5% chromium or die steels, which have inherent low ductility in the air-melt condition, may be applicable to missile design if the ductility can be improved through this new technique in melting steel.

VascoJet Can Be Roll-formed

by Dr. John C. Hamaker, Jr.

LATROBE, PA.—Several years ago we introduced Vasco Jet 1000—an ultra-high-strength steel for landing gear, bolts, and fasteners, high-speed turbine rotors, and critically stressed airframe parts.

Shortly after its introduction, a demand arose for this material in the form of sheet, plate, and welding wire for pressure bottles in liquid-propellant rockets, and cases for high-performance solid-propellant rockets. Several major producers have obtained burst stresses in excess of 300,000 psi on VascoJet 1000 rocket cases, and of liquid nitrogen bottles for the *Hawk* missile guidance system are in production.

Test problems during the initial learning period of applying ultra-high-strength steels to thin, high-performance motor cases instigated a number of notch-strength or crack-propagation test programs in government and industrial laboratories. Results of these investigations indicate that all materials possess a similar, increasing degree of notch sensitivity with increasing strength.

The results show the necessity for eliminating mechanical and metallurgical notches if higher strength levels are to be used for rocket cases. Vacuum melted material together with improved design, fabrication and inspection, have permitted the 240,000 psi uniaxial yield level to be successfully used in full scale VascoJet 1000 cases at **Pratt and Whitney** aircraft. Significant improvements have resulted from replacement of the roll formed and longitudinally welded sheet, by girth-welded continuous cylinders. The cylinders are produced by deep drawing, roll ring forging, machining, roll spinning, or similar methods.

In both present and future planning of missiles and space vehicles, a 5% chrome air hardening steel like VascoJet 1000 offers a number of advantages. Tempering at 1000°F or above to 260-300,000 psi ultimate gives maximum stress relief, freedom from retained sustenite, and hot strength. Weld ability is excellent with structure indistinguishable from the parent mold.

New steels, such as Vasco X5, are currently being produced with 330,000 psi ultimate and 270,000 psi yield strength. Greater strengths would be available from high-speed steels or their modifications having yield strengths in the vicinity of 390,000 psi, if designers and fabricators become accustomed to working with decreased ductility and increased notch sensitivity.

New material manufacturing methods are intriguing. For ribbon-wrap construction, good ultra-high-strength in steel strip has been obtained by austenitic warm working experiments.

Among heat-treated steels, capable of being formed and welded in the soft condition, better ductility and notch toughness at higher strengths are being obtained from new consummable electrode vacuum, induction vacuum, or electron gun melting.

Dr. John C. Hamaker Jr. is director of research and metallurgical engineering for Vanadium - Alloys Steel Co.

SOME OF US WERE WONDERING IF YOU'D MIND SERVING ON THE BOARD AT THE CLUB, JIM. WE'D SURE LIKE...
WHY JIM! I JUST DON'T KNOW WHAT TO SAY!...I WAS SURE YOU...
DADDY! I SIMPLY WON'T MOVE AWAY FROM PEGGY AND SALLY! I WON'T! NO!
BUT DAD! NEXT SEASON I'LL BE ON THE 'A' SQUAD! AND BESIDES I COULDN'T LEAVE ALICE!
OH DEAR! AND WE JUST SPENT $95 ON THOSE NEW DRAPES! AND JIM— WHAT WOULD MOTHER SAY IF WE MOVED SO FAR AWAY?
YOU TAKE JIM, NOW... HE WON'T LET NOBODY BUT ME CUT HIS HAIR—NO SIR!

A personal and (let us hope) encouraging message to an

ENGINEER IN A QUANDARY:

When Dame Destiny crooks her finger at you and says, "Let's go with Bendix in Kansas City, old boy!" you face a set of small problems that are well worth solving . . .

There is an excellent possibility that very soon we shall be offering you the position you've been waiting for. It could be a position at a higher level than the one you now hold and —have little doubt about this—you'll be tempted.

You may, during this period of decision, suffer torments like the engineer we picture above. (We sympathize with him . . . most of us have been through it ourselves.) We'd like to help you then but we know that you yourself must measure these personal cataclysms and weigh them against the advantages of your professional future here. We can only suggest that Kansas City abounds with other potential playmates or sweethearts, other teams hopefully waiting for a star player, and—who knows?— your new drapes may need only slight alteration to fit Kansas City windows.

We're supremely confident that *somehow* you will find the resolution and ingenuity required to solve these problems *if we give you sufficient incentive.*

So let's talk about incentive.

Because we're a long term prime contractor for the AEC, you'll understand why we can say little here about our products except that they are advanced electronic, electro-mechanical devices, designed and manufactured to extremely high levels of reliability. Recently-inaugurated programs make **it very likely** that we can fully utilize your talents, be they in design, production or supervision. This being an engineering organization, all roads lead up; we have no blind alleys.

In general, we need professional men with an appropriate degree in EE, ME, Chem. E, Chemistry, Physics or Mathematics, plus at least 5 years' applicable experience. Following is a sketchy, necessarily incomplete outline of our present needs:

ELECTRONIC DESIGN & DEVELOPMENT
Miniaturized airborne electronic equipment, radar, servo, video, IF amplifiers, vacuum tube applications.

ELECTRONIC AUTOMATION ENGINEERS
Fully automated testing of electronic assemblies.

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Components application consulting to system design engineers; supervisory.

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Potting, and encapsulation, organic finishes, adhesives, laminates, organic resin and/or organic synthesis.

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Systems production engineering; openings at all levels.

MATHEMATICIANS, STATISTICIANS
Applied mathematics; statistics; varied activities include reliability, probability studies, digital computer programming, analysis, mathematical logic, matrices.

You'll have many more facts to weigh—more concrete information regarding the activities mentioned above and other intangible, yet critical facts . . . how the Bendix environment stimulates professional creativity, how this area provides pleasant, easy-going, economical living, educational advantages, cultural and recreational facilities, etc. Right now we can only assure you that—in far less time than you think—you and your family will feel at home here. We're ready to get very specific regarding your financial incentive. We think you'll find our offer of more than passing interest. First we must hear from you. May we, soon?

Write Mr. T. H. Tillman, Professional Personnel, Bendix, Box 303-MX, Kansas City, Missouri.

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KANSAS CITY DIVISION

Better Steels from Research

by J. J. Heger

PITTSBURGH—The **U.S. Steel Corporation** is engaged in a continuing program to extend the usefulness of products of steel and its alloys for the challenging, often changing and novel requirements for high-performance aircraft and ground support equipment.

Current emphasis is in the temperature range from −420°F up to 1200°F. One of the results from this program was X-200, an air-hardening steel in sheets and light plate sections with a minimum yield strength of 230,000 psi. X-200 and other alloy steels, having capabilities of being heat treated to yield strength levels over 200,000 psi, are being tested in the form of small pressure vessels. The results of these hydrostatic burst tests of small bottles will be correlated with laboratory tests of fracture toughness.

An important part of the program embraces extensive studies of the capabilities to convert novel and high-strength alloys developed in our research laboratory into the forms, sizes, and qualities required by the fabricators and designers. The development of new production methods is as important as development of the alloys themselves.

An interesting program is the sandwich rolling of wide sheets. Sandwich rolling consists of placing several plates or sheets of the desired alloy between two heavier carbon steel plates. Side or closure bars of carbon steel are inserted and welded to the edges of the carbon steel plates to make a "composite" slab. In the rolling operation, the slab is rolled in one direction to develop the width ordered and then cross-rolled to develop the length.

J. J. Heger is the Chief Research Engineer, Stainless Steel, at United States Steel Corp.

The composite plate may be further processed by annealing and flattening; the assembly is then sheared around all four edges to eliminate the frame of carbon steel, releasing the internal sheets. Such shearing may be performed after rolling and the individual sheets annealed and flattened, if a rapid cooling rate is required in annealing the alloy.

Significant quantities of sandwich rolled sheets in such compositions as 4340, H-11, AIRSTEEL X-200, and 300M have been produced for development purposes in the fabrication of large cases for high-performance solid-propellant missiles. Recent interest in sandwich-rolled sheets of stainless steel as cover sheets for honey-comb panels has resulted in the intensification of development of sandwich rolled sheets of precipitation hardening stainless steel.

Austenitic Alloys Stronger

by J. Bulina

PITTSBURGH—During the last few years, outstanding advances have been made in the development of alloys for high-temperature applications. Only one important class of alloys is generally referred to as the iron-nickel-chrome austenitic type.

Techniques such as induction vacuum melting, consumable electrode vacuum melting, extrusion and addition of minor elements such as boron, zirconium and rare earths are now common and standard production methods. The improvements realized have been rather substantial.

A good example of how these technology advances have improved an alloy can be shown by comparing the properties of W-545 with other alloys of its class. This alloy has properties essentially equivalent to other high-nickel-content alloys. Consumable electrode vacuum melting improved the cleanliness and quality and made possible additions of more titanium, thus increasing the ability of the alloy to precipitation-harden. The addition of boron to enhance both ductility and strength made it possible to develop W-545 as an improved iron-base austenitic alloy for higher strength and higher temperature applications. The properties are comparable to other higher alloyed materials which would, no doubt, cost more. It is, therefore, reasonable to assume that one may purchase more strength per dollar.

J. Bulina is a Product Development Engineer for the Westinghouse Development Corp.

These alloys are generally used for high-temperature, high-strength applications in steam turbines, gas turbines, missiles, rockets, etc. Another use for these alloys are for high-strength, non-magnetic applications in electrical apparatus. More recently, they have been used at extremely low temperatures, −50 to −300°F, due to their stability of maintaining an austenitic structure.

Structural Aluminum Lighter

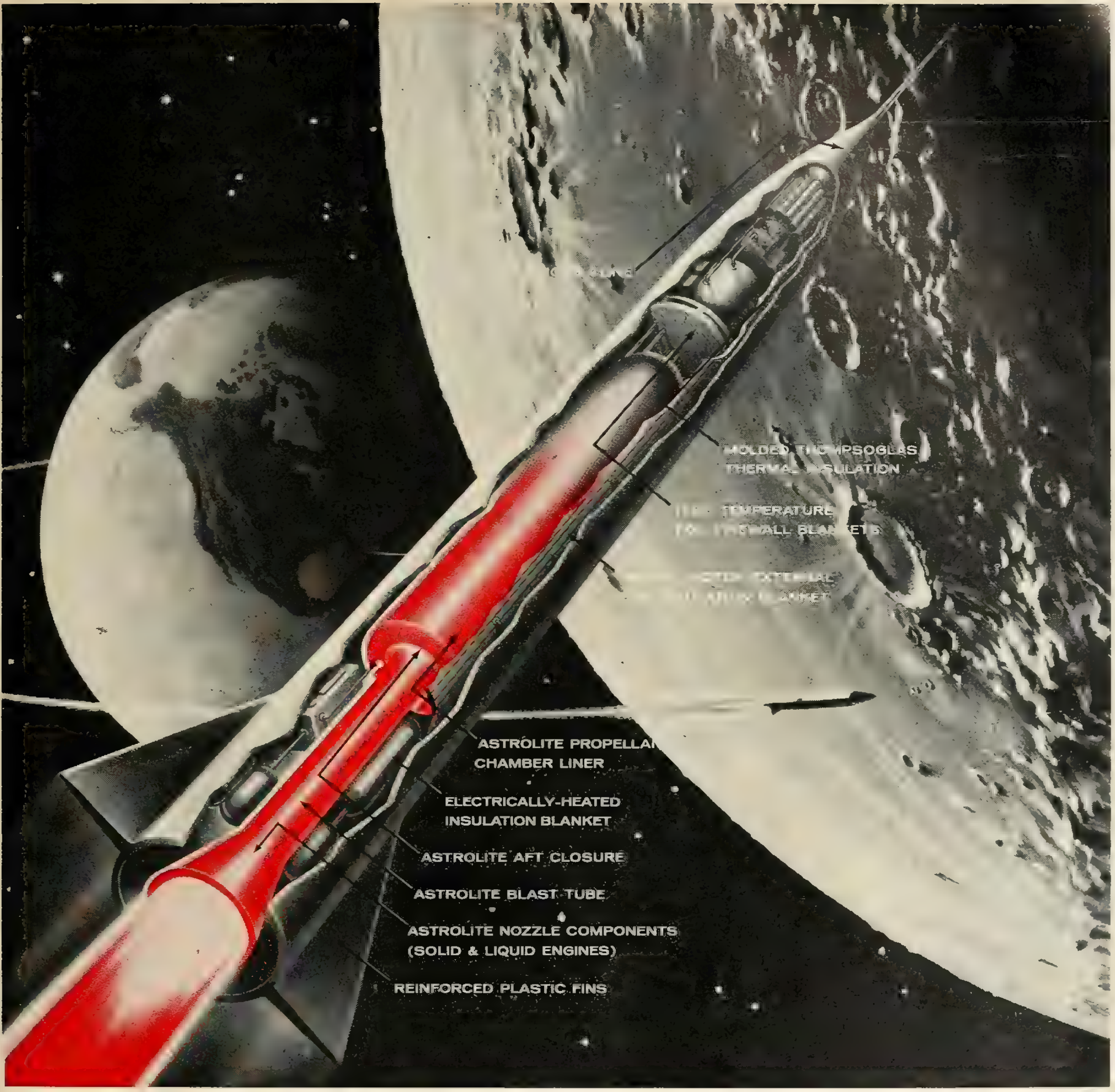
by W. C. Woodward

PITTSBURGH—The room temperature strength-to-weight ratio of high-strength aluminum alloys equals or exceeds those of most competing materials. We have produced 12" diameter, 45" long aluminum cases with a wall thickness of 0.210". They failed at an internal pressure of 3161 psi—or a bursting stress of 94,000 psi, and a strength-to-weight ratio of 935,000 inches. Steel and titanium equivalents of burst and design yield stress in psi are as follows:

Aluminum	Steel	Titanium
94,500	264,000	154,000
77,000	216,000	125,000

Three cases that have been proof tested to design yield will soon be loaded and fired statically. Another is undergoing stress-corrosion tests. No failures have been encountered at stresses below the guaranteed minimum mechanical property level of alloy 7178-T6. New experimental alloys may record strengths 10-to-15% higher.

Aluminum finds many missile applications. Can-type products—one end partially or entirely closed and the other flanged or plain—are used in missile frame shells and tankage, solid rocket fuel containers, missile launchers and special fittings. Tube-type parts—both ends open, with one end having an external or internal flange—find their way into missile frames, launcher tubes,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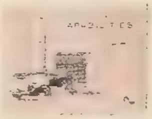

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partial containers for rocket fuels, and special fittings. Both can and tube-type parts are known as forged extrusions.

With the giant 50,000-ton and 35,000-ton presses, huge pressure heads can be drawn from one-piece plate circles. It is also possible to draw a shell with a 60-inch diameter and a 0.50-in. wall thickness.

We have developed special techniques for premium strength castings of alloys A356 and C355. Having very high inherent elongation, these can be heat-treated to higher levels of tensile and yield strength than normally possible. Strength-to-weight ratio for premium strength castings has been increased 50%—more in some cases—over values given in Federal Specification 00-A601 for alloys 356 and 355.

In addition we have developed four aluminum powder metallurgy (APM) alloys with excellent mechanical properties in the 500°F to 1000°F range. These alloys are M257, M430, M470, and M486. They depend on dispersion hardening for their strength. They do not require heat treatment but are used in the as-fabricated condition. APM alloys are not time sensitive—but have the same properties after 1000 hours at 700°F as after one-half hour. They retain their original room temperature properties after repeated elevated temperature exposures.

W. C. Woodward is Manager, Aircraft and Missile Sales, for the Aluminum Co. of America.

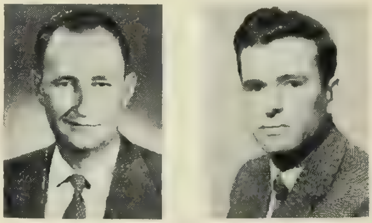
Mathieson Welds Al-Cu Alloy

by Dr. Joseph H. McLain and Dr. Michael J. Pryor

New Haven, Conn.—The high strength and low weight of aluminum results in its wide use in missile structures. Research continues on means of welding high-strength aluminum alloys such as 2014-T6 which retains a good portion of its strength at elevated temperatures and the development of even stronger alloys at higher temperatures.

Of current high-strength alloys, the heat treatable Al-Cu alloy, 2014-T6 enjoys primary favor for missile skins and structural components. Non-heat treatable alloys such as 5083 have been widely used for storing and handling liquid propellants and liquified gases.

Large amounts of copper in aluminum decreases weldability. In 2014-T6 weld cracking often occurs during consumable electrode inert gas welding. Efforts to remedy this include variations of filler alloy composition and application of more effective weld area cooling. As a result, today Al-Cu alloys can be successfully welded if process control is sufficiently careful.



Dr. Joseph H. McLain is in the Energy Division and Dr. Michael J. Pryor in the Metallurgical Research Laboratories of Olin Mathieson Chemical Corp.

Work is now under way to make heat treatable alloys as easily weldable as non-heat treatable alloys.

Efforts to improve aluminum alloy strengths at elevated temperatures involve work with heat-treatable Al-Cu-Ni and Al-Cu-Li-Cd alloys, which show some improvements in performance in certain temperature ranges. The welding techniques for 2014-T6 are applicable to these alloys.

Much more promising are superalloys—mixtures of prealloyed aluminum powders containing large amounts of such elements as chromium, nickel and vanadium. These show excellent properties at temperatures as high as 600°F, and represent a marked step forward. Development of joining techniques for these raises problems not encountered in conventional aluminum technology. Solutions of these problems will, however, further extend the temperature range of aluminum products in the missile and rocket field.

Entire System of Aluminum?

by H. G. McLaughlin

Oakland, Calif.—Aluminum, the "workhorse metal of the Air Age," is also playing a vital role in our new age of the missile.

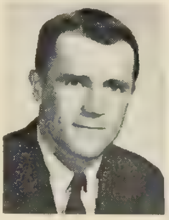
Conceivably, an entire missile system could be assembled from aluminum parts which are, or have been used successfully in missile developments. Such a composite would include aluminum frame, skin, wings, wing spars, nose-cone structure, tailfins, brackets, wiring systems, fuel tanks, piping, fasteners, motor heads, rocket motor tubes, solid-propellant core molds, electronic components in the guidance system and numerous ground support units.

The proven qualities of aluminum—high strength-to-weight ratio, workability, low maintenance requirements, economy, adaptability, availability—will continue to stand it in good stead with the decision-making groups in the missile industry.

But with the tremendous rate of change in the missile industry, will this versatile metal continue its role? We firmly believe that it will. New aluminum alloys will be added to those already used, and more engineers and production men will learn about and use recently developed weldable, high-strength, non-heat-treatable alloys such as 5083 and 5086 (principal alloying constituents are 4% to 4½% magnesium and manganese as a lesser addition).

In addition to many other missile structural applications, aluminum is becoming an important material in the cryogenic field. Its alloy properties improve at ultra-low-temperature levels and this, with the ability to take a sound porosity-free weld, has made these new alloys particularly important as liquid gas storage and transportation containers.

High-temperature alloys have already been developed especially for



H. G. McLaughlin is Manager, Defense Industry Sales, for Kaiser Aluminum & Chemical Sales, Inc.

missiles and high-speed aircraft. Such alloys now available include 2020, 2219, 2618 and most recently 2119 which, as an example, typically maintains a 23,000-psi yield after a half-hour exposure at 500°F.

Aluminum Alloys Easily Welded

by Melvin C. Duke

SHEFFIELD, ALA.—In 1952, sheet aluminum alloys used in the *Redstone* were mostly of the 0.90 and .125" thickness with a tensile yield strength of 38,000 psi. Today the same missiles use a newer aluminum alloy of comparable .063 and .080" thickness and 51,000 psi.

Early *Redstones* had weld joint tensiles of 24,000 psi. Today, with improved welding rods and techniques we surpass 38,000 psi.

The more than 12,000 inches of welding on the *Redstone* and its sister, the *Jupiter C*, are X-rayed—sometimes repeatedly. We use over 1600 sheets of X-ray film on each missile shell.

To perform better welding at lower cost, we have developed new equipment and techniques. Our new aluminum back-up welding bar dissipates heat more rapidly than stainless steel.

We also designed gantry welders to handle the large aluminum *Redstone* shells. Eight shells, six feet in diameter, varying from 24 to 60 inches long, have to be welded together to make the *Redstone* fuel tank. Maximum T.I.R. on this 34-foot section is 0.031 inches. Girth welding is done on an automatic Sigma SWM-3 machine at speeds up to 55 inches per minute. Power settings are usually 160-225 amps, 20-22 volts.

Several power interlocks are provided to prevent machines with heavy electrical current drains from starting during the critical weld cycle. There has never been a single case of a *Redstone* missile failing because of poor welding.

Shop technicians teamed with the scientists and designers in the switch made in the *Jupiter C* rockets from steel to aluminum in the rudder control assemblies.

The problem was weight, and Red-

Melvin C. Duke is the manager of the Missiles Plant of the Reynolds Metals Company.

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If you're having trouble testing complex electro-mechanical systems, it will pay you to investigate DIT-MCO's 250F2M Electro-Mechanical Systems Analyzer. It is specially designed to control and test integrated devices and their associated wiring by simulating controlling assemblies and monitoring their action.

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1. Actuate all necessary resistive devices and provide termination-to-termination tests of each circuit for continuity and discontinuity.
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4. Provide switching capabilities which enable monitoring of circuit conditions with external detecting devices.

These capabilities make it possible to achieve extremely high standards with complex relay chassis and similar systems, thus eliminating borderline errors which can lead to malfunction under operating conditions.

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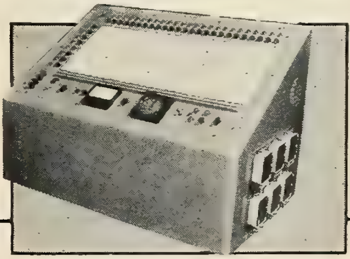


SPECIFICATIONS:

1. Continuity Test
   - A. Test Voltage .... 28 V.D.C.
   - B. Continuity Current .... 1 ampere
   - C. Continuity Resistance .... adjustable from 0.3 ohms to 10 ohms
2. Continuity-Discontinuity Test
   - A. Test Voltage .... 28 V.D.C.
   - B. Continuity Current .... 1 ampere
   - C. Continuity Resistance .. 0.3 ohms to 10 ohms
   - D. Discontinuity Resistance .... 2.5 megohms reject, 3 megohms accept
3. Short Test
   - A. Test Voltage .... 28 V.D.C.
   - B. Test Current .... 0.03 ma (max)
   - C. Short Resistance Range .... 2.5 megohms reject, 3 megohms accept
4. Ohmmeter
   - A. Range .... 0 to 200 megohms
   - B. Accuracy .... ±3%
5. Timer (Standard)
   - A. 60 minute range, 0.2 second scale division
   - B. Accuracy .. 0.1 sec. per operation at 60 cycles

   Timer (Optional)
   - A. 60 minute range, 0.01 second scale division
   - B. Accuracy .. 0.002% per operation ±1 division
6. Power Requirements
   - A. 100 to 125 V.A.C. 55 to 65 cycles (standard timer)
   - B. 100 to 125 V.A.C. 50 to 400 cycles (optional timer)
7. External Energization
   - A. 28 V.D.C. and 110 V.A.C., 60 cycles are provided for external energization of relays or other resistive devices, isolated from test voltage.
   - B. Other voltages may be supplied by external power supplies and switched as external energization or other test purposes.

stone Arsenal specified aluminum as the answer for this welded torsion bar and sprocket wheel assembly. A strong and highly machinable aluminum alloy was chosen. For an extra measure of safety, heat treatment and artificial aging of the component parts were specified. As a further assurance of strength we decided to heat treat and age after welding. The success of the *Jupiter C* and *Juno* rockets with this assembly made history.

Copper Passes Rugged Tests

by T. E. Veltfort

New York—Highly interesting to metals men was the recent revelation that the nose cones for both the *Atlas* and *Thor* ballistic missiles are of forged copper.

The **Lockheed** *X-17* research rocket also has a copper nose plated with extremely smooth nickel. This rocket has been used extensively in missile research and to launch nuclear bombs which were burst to form the artificial radiation belt in Project *Argus.*

Copper's heat conductivity enables it to distribute heat rapidly and evenly during the brief—but crucial—period of re-entry.

Dr. J. D. Stewart of **General Electric's** Missiles and Space Vehicles Department has pointed out (M/R June 8, 1959) that the copper heat sink re-entry vehicle has been successfully flight tested over a wide range of re-entry conditions. The data capsule has survived water impact and has been recovered intact from a large number of flights.

T. E. Veltfort is managing director of the Copper & Brass Research Assn.

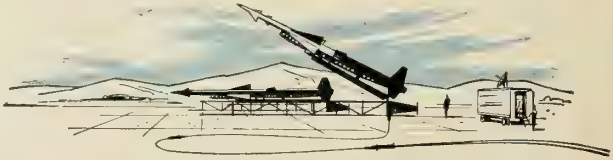
The copper heat sink provided the necessary thermal protection for internal systems. Dr. Stewart further noted that no surface melting occurred and the aerodynamic performance of the re-entry vehicle has been good. The development, he said in conclusion, has been justified by flight tests.

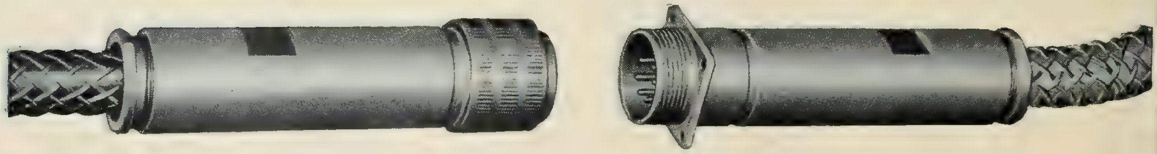
Besides the important nose cone application, a recent survey of major missile contractors by **Copper and Brass Research Assn.** revealed that the copper metals are vital to missile design and performance, chiefly in electrical and electronic components and apparatus.

For example, in **Western Electric's** *Nike-Hercules,* copper's superior electrical conductivity makes it imperative for wiring, as well as for electrical splices, sleeves, plugs, jumpers and bus bars. The switch in the *Nike-Hercules* warhead section has copper gears and allied parts because of corrosion resistance and machinability.

Nike's thrust limiter has a beryllium-copper snap ring, and the missile's solenoid four-way valve embodies a phosphor bronze spring assembly.

Lockheed Aircraft Corp. pointed





Why it pays you to specify

Bendix QWL Electrical Connectors for use with Multi-conductor Cable

For use with multi-conductor cable on missile launching, ground radar, and other equipment, the Bendix* QWL Electrical Connector meets the highest standards of design and performance.

A heavy-duty waterproof power and control connector, the QWL Series provides outstanding features: • The strength of machined bar stock aluminum with shock resistance and pressurization of resilient inserts. • The fast mating and disconnecting of a modified double stub thread. • The resistance to loosening under vibration provided by special tapered cross-section thread design. (Easily hand cleaned when contaminated with mud or sand.) • The outstanding resistance to corrosion and abrasion of an aluminum surface with the case hardening effect of Alumilite 225 anodic finish. • The firm anchoring of cable and effective waterproofing provided by the cable-compressing gland used within the cable accessory. • The watertight connector assembly assured by neoprene sealing gaskets. • The additional cable locking produced by a cable accessory designed to accommodate a Kellems stainless steel wire strain relief grip. • Prevention of inadvertent loosening insured by a left-hand accessory thread. • The high current capacity and low voltage drop of high-grade copper alloy contacts. Contact sizes 16 and 12 are closed entry design.

These are a few of the reasons it will pay you to specify the Bendix QWL electrical connector for the job that requires exceptional performance over long periods of time. *TRADEMARK

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Bendix
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out that, along with electrical-electronic applications, *Polaris'* use of copper includes connector pins and, because of excellent heat conductivity, chill bars for welding.

George F. Douglas, Vice President, Engineering, at **Northrop Division of Northrop Aircraft,** said his company uses copper metals for electrical conductors, as well as for non-magnetic, non-sparking, bearings and spring applications. Typical titles in a materials manual at Norair include Copper, Naval Brass, Commercial Bronze, and Aluminum Bronze bar; Copper sheet and plate, Beryllium Copper Strip, Phosphor Bronze sheet and plate, and Copper and Phosphor Bronze wire.

Titanium Increases Payload

by E. F. Erbin

NEW YORK—Weight savings inherent in titanium construction is perhaps best illustrated in the successful firing of *Pioneer IV*.

Titanium reduced fourth-stage weight enough that two pounds of instrumentation—in effect a 20% increase—could be added to the payload.

The titanium alloy grade selected for this casing was Ti-6A1-4V. This grade is currently titanium's leading contribution to the missiles manufacturing industry, although applications have been reported for unalloyed material, as well as Ti-5A1-2.5 Sn (in the Project *Mercury* capsule).

This Ti-6A1-4V grade can be heat-treated to tensile strengths in excess of 160,000 psi, retains its properties to –320°F, provides fusion-welded joints with useful ductility, and offers corrosion resistance not normally associated with structural metals.

Ti-6A1-4V is available in all mill shapes. It particularly lends itself to forging, since work temperatures are considerably below its beta transus. Beta titanium, however, will virtually eclipse all other titanium grades in solid-propellant missiles when the smoke of controversy lifts from notch sensitivity testing. Beta titanium has provided a burst strength-to-weight ratio consistently over 1 million, with recent results reaching 1.4 million. This demonstrates the alloy's weld and base metal strength under triaxial loading conditions and its notch insensitivity.

While additional details must necessarily originate from such firms as **Aerojet-General, Curtiss-Wright, Martin, Pratt & Whitney** or **Thompson Products,** the titanium industry can verify these characteristics of the beta alloy: (1.) In the annealed condition, it is quite ductile and readily formable. Since it is highly alloyed, air cooling from solution annealing temperatures retains the soft dispersion hardenable beta phase. Large increases in strength can be obtained by simple aging at temperatures between 800°F and 900°F. Quenching is not required. (2.) Various welding and heat treating procedures are available for obtaining combinations of high base metal strength and weld ductility. (3.) Titanium's basic resistance to corrosion is unchanged by the alloying additions.

Price is conventionally cited as a limiting factor in selection and use of titanium. But all too often the factors which modify the initial price tag are overlooked. For example, fabrication costs for titanium and steel are often equivalent. Since these costs normally outrun input metal costs, the price difference between completed assemblies of both metals is not as severe as originally pictured. Further, the lighter density of titanium is an important element in pricing, since one pound of titanium will do the same task as almost two pounds of steel.

Mr. E. F. Erbin is Assistant Manager of Technical Services with the Titanium Metals Corporation of America.

Malleable Has Good $$ Ratio

by Malleable Iron Founders Society

CLEVELAND—Malleable iron's suitability for selected applications in space vehicles is supported by the results of a three-year testing program just completed at Purdue University. These demonstrated malleable iron's reliable performance at 800°, 1000°, and 1200°F in stressed applications.

Malleable iron is a cast ferrous alloy rendered tough and ductile in a controlled heat treatment. Malleable thus attains many "steel-like" characteristics without the costly refining operations necessary in steelmaking. These characteristics include high tensile strength, ductility, excellent machining properties, impact strength and wear resistance—combining to give the material a favorable "strength-to-dollar" ratio.

The material differs from cast iron in that it is capable of absorbing shock and, under extreme loads, will bend or deform as much as 20% before it fractures. Measure of this attribute is its elongation range—minimum standards of 18% and 10% for the two standard grades of malleable; between 4% and 10% for the harder pearlitic grades.

At the culmination of the high-temperature study, no evidence was found of changes in structure or performance of the material during test periods which lasted from one to 2300 hours. The significant result was the fact that the stress-rupture curves for malleable irons do not reach a point at which they break sharply downward.

An application which takes advantage of malleable iron's rugged strength and ductility is a bead ring used in a carrier for the U.S. Navy's *Growler* and *Grayback* missiles. The ring, assembled of six close-tolerance malleable castings, is part of the air spring mechanism.

Ductility is essential in this application to insure coining to close tolerances—a time/dollar-saving step compared with machining.

Beryllium Lightens Gyros

by O. F. Quartullo

SARASOTA, FLA.—Although most applications involving the use of pure beryllium components are classified, a high degree of success has been obtained in inertial guidance system parts and gyroscopes fabricated from this sophisticated metal.

Improved function has been so pointed and remarkable that many programs which were in the research and development stage as recently as a year ago are now in production and utilizing the special qualities inherent in beryllium to insure the high degree of accuracy and stability required for optimum performance in guidance equipment. Briefly, these qualities are: light

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CHANCE VOUGHT
DALLAS, TEXAS

missile suppliers speak: Metals

weight, high melting point, high strength-to-weight ratio, high heat absorbency and thermal properties, and, most important in the categories outlined above, extreme stability.

An ultra-precise gyro part machined to 50 millionths of an inch tolerances will retain its dimensional stability under widespread temperature conditions and function more efficiently than any other known material.

Some other applications for precision machined beryllium parts are: X-ray cameras, high-speed aircraft cameras, nuclear power reactors, underwater instruments (where beryllium's corrosion resistance is a factor), gas turbine engine parts, rocket engine components, memory wheels, and memory discs.

The state of beryllium machining is such that configurations which have sectional cut-outs that would tend to distort and destroy tolerance requirements in other metals are being successfully produced of beryllium.

Future applications and fabricating technology, in a general sense, are broad in scope. The vast combined engineering knowledge of American industry will conceive and bring to practical levels new applications for machined beryllium parts which can be favorably analyzed on a "cost to worth" basis. Machining and fabricating technology will advance with this increased requirement, and better and less costly components will result.

O. F. Quartullo is the president of the American Beryllium Co.

Metal Working

100% Efficient Welds Needed

by Ludwig Roth

San Diego, Calif.—Strength-to-weight requirements for solid rocket cases make it mandatory to produce weld joints that have 100% strength efficiency across the weld and 100% reliability.

The part geometry must be free of abrupt discontinuities at the junction of the weld and parent material, and the chemistry of the weld must be carefully controlled so that its response to heat treatment is comparable to that of the parent material.

We use three methods for producing weldments that fulfill these requirements. They are cold weld planishing, hot weld forging, and weld remelt with a mechanically controlled oscillating electrode.

Cold weld planishing has been used on sheet metal parts for several years. It is accomplished by passing the weld under steel pressure rolls one or more times to reduce the weld reinforcement height. It is normally used on material from .020" to .125" to improve the weld geometry and increase weld strength by work hardening.

The hot weld forging method was developed for material thicknesses greater than .125". In hot weld forging the edge of the sheet to be welded is "hot upset" adjacent to the weld seam. The weld is then made in the conventional manner. The upset area is heated to forging temperature and forged either by a pneumatic hammer or planishing rolls until the thickness of the upset area is similar to that of the parent material.

This process produces a homogeneous assembly wherein the weld is difficult to detect by X-ray or micro examination.

• **100% efficient**—In the mechanical oscillation remelt method, the weld

Ludwig Roth is chief engineer in the Research and Development Engineering Department, Solar Aircraft Co.

is made in the conventional manner with an automatic welding machine. The weld reinforcement on both sides of the weld is ground to a uniform height of 15 mils, then each side is remelted with a mechanical oscillating motion. The finished weld is 10 mils in height with a smooth contour. Such welds have 100% joint efficiency.

Cold weld planishing is the cheapest method of improving weldments. But many vehicles are made from material thicknesses above the range for this process. The mechanical oscillation process is least costly for thicker materials.

Alloy mechanical and metallurgical evaluations include current and proposed materials for rocket motor use, such as Ladish D6, X-200, 4340 and modifications, MS-1, 300M. The aim is to select the optimum material for the application and determine fabrication requirements. Research and development is directed toward evaluating all-beta high-strength titanium alloys, metal ribbon-wrapped structures and non-ferrous metals combined with heat-treatable steel. Non-ferrous metals appear applicable for components such as igniter and nozzle bosses.

Joining dissimilar metals poses difficult problems. Braze joining or diffusion bonding appear to be applicable for future rockets.

Braze joining offers excellent potential for reducing weight and improving reliability of all heat-treatable steel cases. We have shown the effectiveness of a process using braze alloys developed for joining igniter bosses on two current development cases.

• **Reinforcing shear loads**—Brazed sandwich structures consisting of honeycomb core braze-joined to facings is an excellent structural material. Optimum strength-to-weight ratio, high inherent rigidity and high-temperature capabilities indicate possibilities for efficient minimum-weight structures. Current developments include evaluation of honeycomb core for shear-load reinforcement at the case to closure joints.

High refractory metals and ceramics assembled to unique designs offer potential solutions for advanced nozzle structures. Thin-walled tungsten supported by tantalum marcel is currently being developed for rocket blast panels and nozzle linings. Problems with tungsten include forming and joining; special brazing and welding techniques have been developed.

Refractory metal open-faced sandwich structures provide an excellent medium for supporting high-temperature ceramics and reinforced plastics. Zirconium oxide-filled tungsten honeycomb resists temperatures over 4500°F for most current combustion periods. Borides, silicides and oxides promise to meet requirements of higher temperatures and longer periods of operation.

Forging Cuts Component Cost

by William C. Kunkler

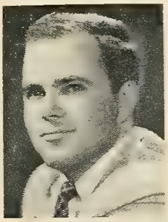
Worcester, Mass.—The function of forging by plastic deformation is to contribute improved engineering properties and desired shape to the metal producer's cast ingot, sintered ingot or mill product.

Forged integral components permit reduction in the number of mechanical and welded joints and elimination of welds in critical areas resulting in reduced stress concentrations, increased reliability and weight savings.

Material utilization is often misinterpreted as a reliable cost index for a comparison between different manufacturing methods such as casting, forging and sheet metal fabrication. Actually the component cost at the point of assembly is the only accurate basis for comparison. This analysis introduces, in addition to added operations, the cost of inspection and test, quality control, re-work and rejection. The use of forging reduces and in some cases eliminates these expenses.

Payload components for re-entry and space vehicles have the most critical need for weight saving. Re-entry shields and structural parts of forged beryllium offer this weight saving. Forged beryllium provides increased advantages in soundness, tensile strength, ductility, machinability, material utilization and productibility. Hollow shapes of 160 lb. have been successfully forged and subsequently machined. Press-forged upset sheet is being recognized as the best starting point for beryllium sheet. Sheet blanks 40" and more in diameter are a present capability. Guidance components in beryllium are also being developed.

Inclosures for *Polaris, Minuteman* and *Pershing* solid-propellant motor casing, under high internal pressure and with many bosses and attachment points, must have a high strength-weight ratio and reliability. They must also be as free as possible of notches and stress concentrations and take moderate heat for a short time.



William C. Kunkler is senior application engineer in the Research and Development Department, Wyman-Gordon Co.

Two materials are dominating this application. Low-alloy, high-strength steels such as 300 M, X200, H-11, D6, types and AMS 6428 offer a material with metallurgical and production experience, high strength at relatively low cost, with a great flexibility in heat treatment. Steel closures up to 65" in diameter are being forged with integral skirts provided in some cases for spinning out into the cylindrical section. The second material is the all-beta titanium alloy B120VCA, which develops its outstanding strength by an aging heat treatment after cold working. Extensive work is being expended in producing closures currently up to 41" diameter. A 180,000 psi yield strength, 200,000 psi ultimate and 5% elongation appear feasible. At this level, B120VCA equals steel at 290,000 yield strength.

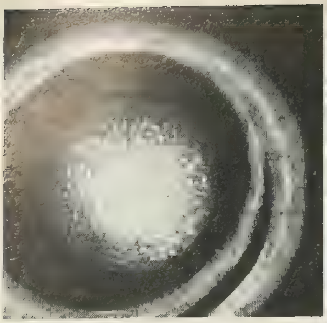
Forging development programs are under way and being proposed for sintered tungsten and tantalum alloys to meet higher temperatures. Many believe that only a forged component will have sufficient resistance to erosion and thermal shock plus reliability.

Deep Drawing Obviates Welds

by Larry Shiller

Los Angeles—It has become increasingly evident that the designers of solid-propellant rocket motor cases want to produce one-piece cases within the near future and thereby attain improved reliability and performance characteristics. The immediate objective is to eliminate as much welding as practicable, especially longitudinal seams.

We have had extensive experience over many years in deep-drawing millions of one-piece jatos, rocket motors, cartridge cases, other ordnance items and cylinders for high pressure gas and hydraulic applications. Rocket motor cases in which the pressure vessel sections have been produced by deep-drawing as a single piece include the 15 KS 1000 *Jato, Sparrow, Rat, Falcon, Terrier,* and *Hawk.* The AISI 4130 steel "as drawn" case for the



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Douglas Aircraft Company, Inc.
Santa Monica, Calif.

missile suppliers speak: Metal Working

Hawk motor is 14″ by 96′ long.

Experience with these parts suggested the feasibility of employing the deep-draw technique to manufacture one-piece rocket motor cases from the higher strength steels, thereby eliminating the need for longitudinal seams. Materials including AISI 4340, Airsteel X200, Potomac A, Crucible 56, Tricent, UHS 260, Vascojet 1000, Crucible 218, MBMC #1, and Ladish D6 and D9 were evaluated. After preliminary forming experiments, the first four steels were selected for fabrication into pressure vessels that would indicate problems and results in larger size, full-scale motor cases for such programs as *Polaris* and *Minuteman.*

Deep-draw tooling was available for the fabrication of chambers 10″ in diameter by 12″ long with a 2 to 1 elliptical head and a .045″ mean wall thickness. Two chambers were joined with a central girth weld to produce a pressure vessel 10″ in diameter by 24″ long.

The four steels selected showed satisfactory forming characteristics. About a dozen chambers from each of these materials were fabricated and heat-treated to various strength levels in excess of 190,000 psi yield strength, .2% offset. The test results have been excellent at the 200,000 to 210,000 psi yield strength level. At this level, with few exceptions, burst strengths calculated on the thin wall pressure vessel formula have exceeded 240,000 psi.

Larry Shiller is chief research and development engineer, Norris Division, Norris Thermador - Corporation.

Some of these vessels, particularly those made from Crucible 56 and Potomac A, have withstood pressure cycling at a calculated hoop stress of 222,000 psi for at least 10 cycles without any evidence of failure. It appears probable that pressure chambers for various missiles can be designed to the 210,000 psi yield strength level.

We are in a position to produce one-piece rocket pressure chambers with existing equipment that have typical dimensions of 37.5″ x 65″ or 54″ x 35″. Longer cases can be readily produced without longitudinal seams by joining two or more cylindrical sections with a girth weld, or welds. In many cases it is practicable to further reduce weldments by forming head and aft closure attachments integral with the cylindrical sections.

By designing simplified and comparatively low-cost press equipment and tools we can deep-draw cases up to about 66″ x 144″ in one piece.

Shear Forming Spells Saving

by Wayne Stone

STRATFORD, CONN.—The desirability of manufacturing large missile components in one piece has made shear forming almost mandatory, stimulating intensive advancement in the state-of-the-art. Machine capacities have increased to 60″ diameter with 120″ diameter in demand. Starting wall thicknesses of up to 1″ have been shear formed.

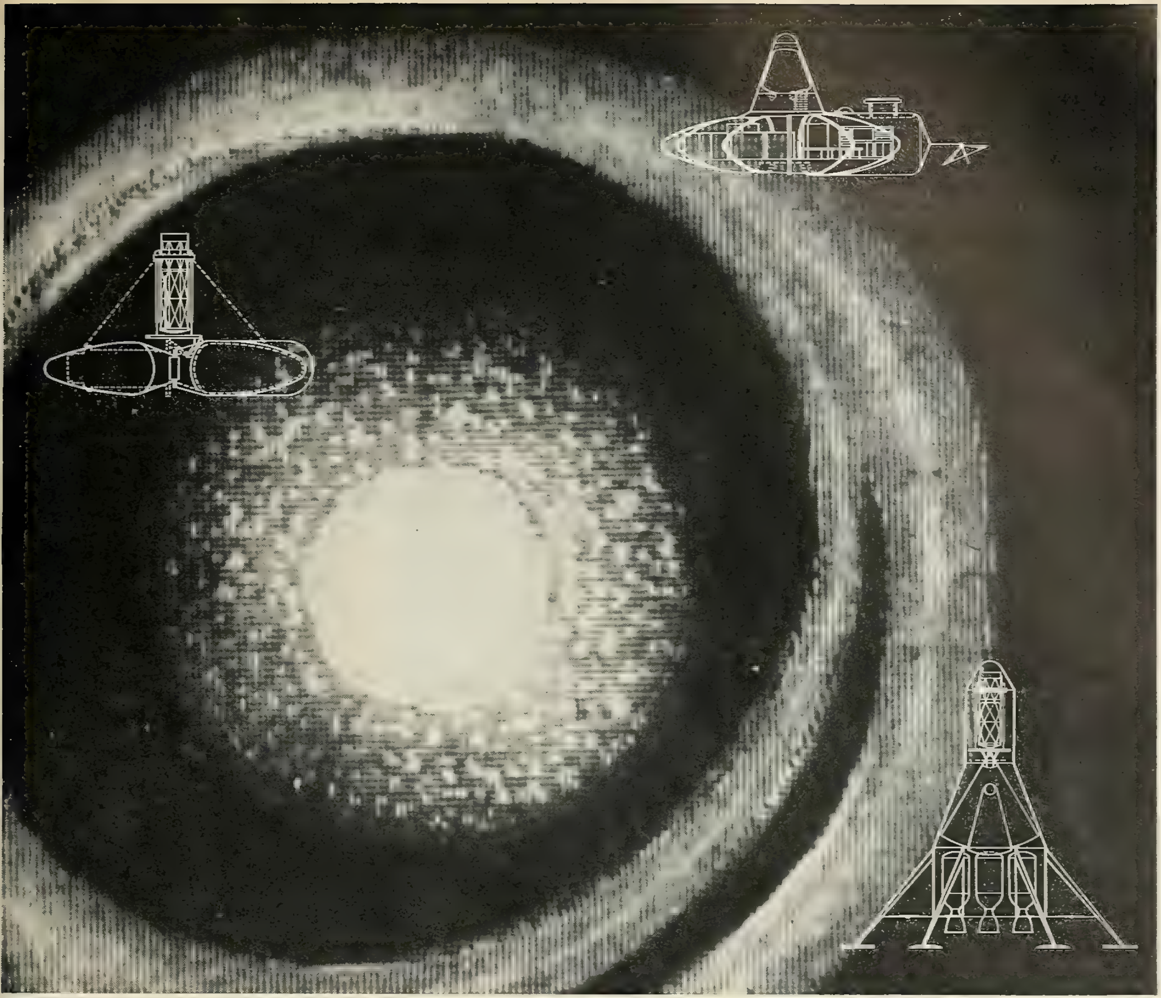
The method has been applied to a wide variety of materials including low-carbon steel, all types of aluminum, type 300 stainless steels, Inconel, Timken 17-22A (S), Vascojet 1000, Thermold J, Tricent, titanium, A 286 and N-155. Despite high forming pressures, no appreciable reduction in physical properties results. Micro-structure analysis shows no evidence of fracture developing in the crystalline structure.

Shear forming lends itself to many shapes including conical, cylindrical, ogive, parabolic, hyperbolic, venturi and spherical—all with either thin, heavy or tapered wall thicknesses.

Predictability of shear forming applications and limitations is being dependably established. Lead time is reduced and the aero-space industry using this method can produce superior parts at less cost with increased material utilization.

Parts are shear formed to accurate

Wayne Stone is supervisor, manufacturing engineering, for the Lycoming Division, Avco Corp.



New styles for the man-about-space

Every time a space traveler leaves home (earth), he has to wrap himself in the complete environment necessary to his physiological and psychological well-being. Styling sealed space capsules to suit man's every requirement has been a major project at Douglas for more than ten years. Forty basic human factors areas were explored in these studies. Now Douglas engineers have evolved plans for practical space ships, space stations and moon stations in which men can live and work with security thousands of miles from their home planet. We are seeking qualified engineers and scientists who can aid us in furthering these and other out-of-this-world but very down-to-earth projects. Some of our immediate needs are listed on the facing page.

Dr. Eugene Konecci, Head, Life Sciences Section, reviews a new concept in space cabin design with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

ID requirements with surfaces burnished to a smooth finish and only critical OD dimensions requiring machining. As an example, the repetitive production of diameter and wall thickness to within .002″ on a 50″ diameter spherical contour of AMS 4340, is indicative of present fabrication control. Finish is better than 32 RMS.

Pounds of forging weight and many man hours are being saved. Components heretofore considered impractical or impossible to manufacture as a single piece are being so fabricated.

Missiles demand close-toleranced, comparatively thin-walled, large diameter cylinders for rocket motor casings. Shear forming is a fabrication technique capable of producing such parts without the disadvantages of other methods. It presents a tremendous potential in cost reduction and saving of highly critical materials.

Spinning Fills Many Needs

by John H. Owens

MILWAUKEE—Metal spinning made its initial appearance in the United States sometime in the 17th century insofar as records reveal. Paul Revere dabbled in the art. So did other copper and silversmiths who confined the craft to the production of jewelry holloware, silver and gold chalices, and other precious vessels.

Today, metal spinning is a prime source for diverse missile components, ranging from skin sections produced for the *Honest John* to massive bulkheads for the *Jupiter*. Other important jobs produced in many sizes and in a wide range of alloys are: missile skin stiffener rings and "Z" sections; inert warheads; special oil containers; tank heads for missile fuel containers; control housings for gimbal mechanisms and gyroscopes; gondola sections for high-altitude balloons; cone spinnings for missile fuel tanks; and tank heads used in shipping containers for rocket motors.

As in other industries, automation plus hydraulic power are doing much to broaden the scope of the metal spinning industry. We pioneered the transformation from manual to mechanical to hydraulic power.

Hydraulic lathes, still under wraps in our plant because of their advanced design, include powerful robot spinning machines. These machines are now rapidly producing increasingly heavier gauges and ever-larger diameters for missile and other industries.

The internal structures spun for many missile jobs have involved extremely heavy gauges in difficult to shape alloys. The massive carrier case for the nose cone of the *Atlas* was spun automatically with tremendous forces by hydraulic power on the special "MET-L-FLO" lathes, originally designed and developed by us.

Metal spinning is nominal in cost compared to other methods of forming. It is available in such a wide range of metals, weights, and shapes that it plays an important part in experimental and development work.

Metal spinning can and often does: improve product design and appearance; reduce production time and labor; offer dollar savings in cost-per-unit; increase product efficiency; decrease weight; simplify fabrication; offer savings in tooling, both in time and cost through elimination of expensive dies, jigs, and fixtures; lower costs of tool modification.

John H. Owens is on the public relations staff of Spincraft Inc.

A few years ago the spinning of simple shapes in 1/16″ copper was considered remarkable. Now aluminum in gauges of ¾″ and more is successfully spun.

At our plants, tiny 2″ cups stand side by side with huge 130″ stainless steel covers and deep cylinders. These components are spun from all kinds of metals; copper, aluminum, brass, sheet steel, and stainless steel.

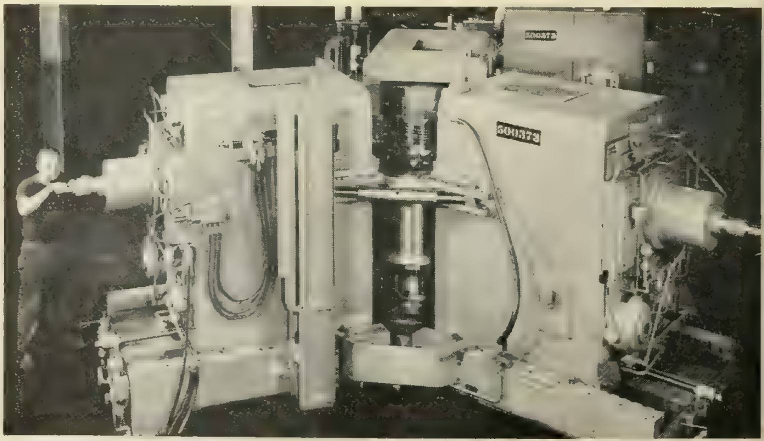
Roll Forming Art Advances

by Richard H. Gade

BRISTOL, PA.—Production rocket motor cases ranging from 14″ diameter to 54″ diameter and up to 78″ long, with finished wall thickness ranges from .065″ to .181″ have been produced by roll forming within tolerances of ±.004″. Roll forming permits the use of heavier-walled short cylindrical blanks, either machined ring forgings or wrapped and longitudinally welded cylinders of sheet material.

The blank is reduced in wall thickness 50% to 65%, sized to the forming mandrel, and increased in length to 2 to 2¾ times. Low alloy, medium carbon steels are roll formed in the spheroidize anneal condition. Consistent results are obtained when the spheroidization is a minimum of 80% to 85%, as determined by metallurgical examination. A slight decarburization appears to be beneficial, and in-

Floturn Equipment



SEAMLESS CYLINDERS are produced with this Floturn machine installed at the Pratt & Whitney plant in East Hartford, Conn.

Richard H. Gade is chief production engineer of Kaiser Fleetwings Inc.

sures that no local carburization exists.

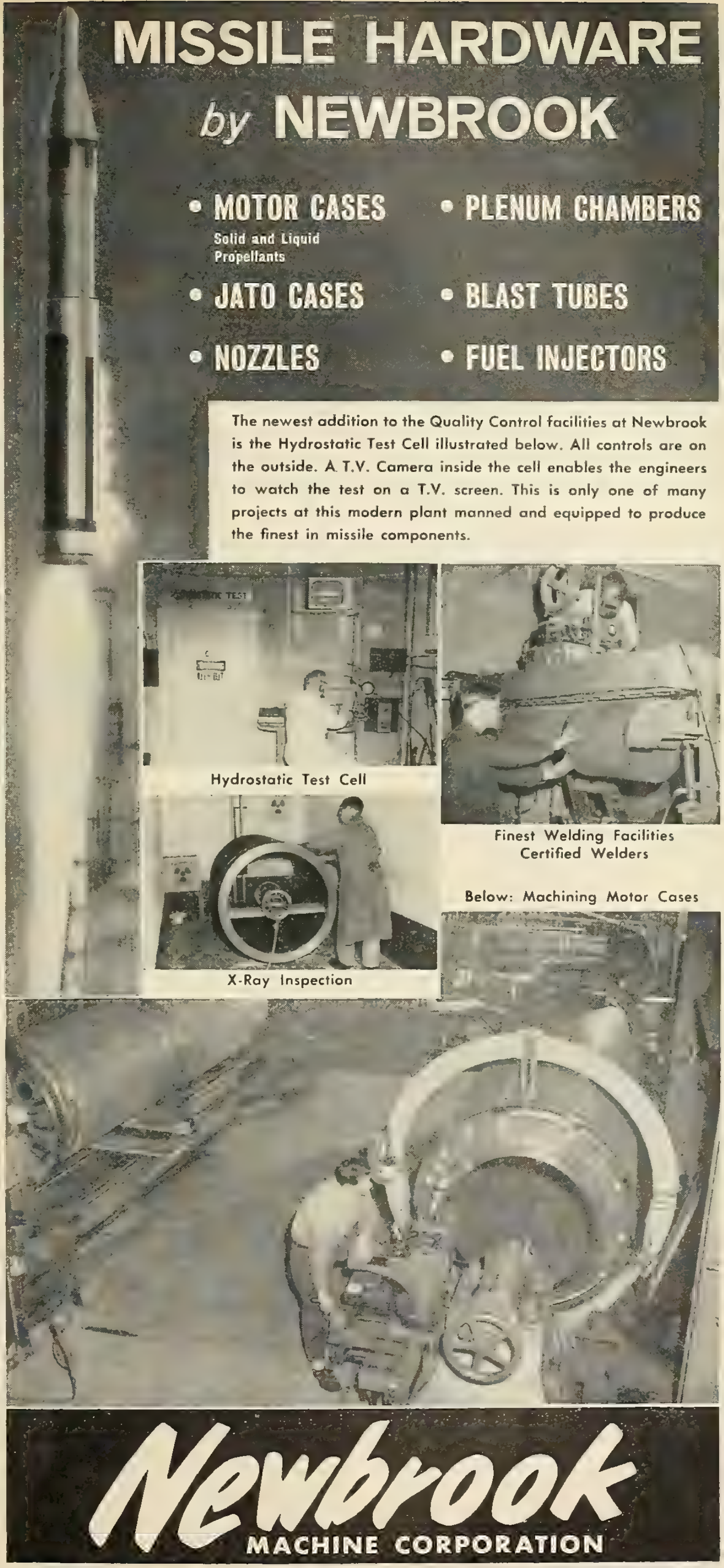
The roll-formed welded blank exhibit a beneficial wroughting and homogenization of the weld area. But roll forming will not heal improper welding. Prior to forming, welds undergo 100% radiographic examination and magnetic particle inspection.

A further advantage of roll-formed welded shells is weight control. Mill tolerance variations in sheet material are ±10% in the gauges presently specified in motor case shells. Roll forming tolerances reduce this variation to 4%, and roll forming further eliminates a design allowance for "weld strength reduction," usually 85-90%.

Body shells have been produced from SAE 4130, SAE 4340, AMS 6434, modified AMS 6434, USS X-200 and Ladish D6AC steels. Vacuum-melted steels have a more consistent level of cleanliness and uniformity. However, air-melted steels have been successfully used.

Shear forming is also employed in producing missile chamber components. Symmetrical bodies of revolution of conical-ogival sections are being produced from 17-7 stainless steel. These parts, 35" in diameter, replace a fabricated weldment made from two deep drawn details and a developed conical weldment. The one-piece shear-formed components are used as pressure vessel heads for a liquid rocket motor system. Elliptical shear-formed motor case heads of 54" diameter have been made from the modified AMS 6434 and USS X-200 steels in limited quantities.

An area of interest is the roll forming of beta titanium weldments. The relatively new beta titanium alloy offers a high strength-to-weight ratio compared with presently available steels. However, the embrittlement of welds in this metal during simple or duplex aging is detrimental in motor case use. Welding after aging lowers the potential strength of the weld area to about 125 k.s.i. (equal to 200 k.s.i. in steel on an equivalent weight basis). Tests indicate that welds in beta titanium roll formed to a 40% reduction have aging characteristics similar to the base metal. Consequently, a welded, roll formed, and aged sequence of processing a beta titanium motor case shell may offer a significant advance in strength-to-weight ratio.



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Hydrostatic Test Cell

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Below: Machining Motor Cases

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Missile Machining Demands Accuracy Control

by A. B. Albrecht

SIDNEY, OHIO—Most missile hardware requires both internal and external machining with the added problem of chucking on thin-wall sections. High-temperature requirements in this field have increased the use of the "superalloys" and materials such as zirconium and beryllium. The cost per lb. of these alloys is high, and initial forging or casting quite often represents a sizable investment. Thus control of accuracy and reduction in scrap losses are important factors.

To maintain the repetitive accuracy desired in contour-turning nose cones, nozzles, accumulators, closure domes, etc., most contract shops are utilizing "Air-Gage Tracer" lathes. Accurate template reproduction assures built-in inspection on complex contours which would otherwise require costly gaging. Final finish on most parts is below 62-microinch, and standard tolerances are ±.001″.

The missile frame, bulkhead, enclosure, and motor case are often of such large diameter that special machines are required to handle these parts efficiently. The design of the Series 170 Monarch Missile Lathe was based upon the need for greater accuracy in a large swing lathe for machining these parts. This 85″ swing lathe is template-controlled, and provides a wide range of spindle speeds; including a low range for thread milling on the missile frame.

The small prototype shops have long shared the responsibility for machining components to meet engineering test schedules in the missile field. Lead time in most cases is short, and design changes are frequent. The thin-wall sections and cold-working tendencies of the high-temperature alloys dictate single point tracer tools.

A. B. Albrecht is a technical consultant to the Monarch Machine Tool Co.

The basic machine of the industry has been the standard engine lathe with "Air-Gage Tracer" controls. Low setup time and flexibility are major factors for low-cost production of missile hardware. Numerical controlled machines are entering the field and are being considered for the general machining of nose cones, radomes, bodies and adapters. The complex contours call for a "path" type control which adds to the initial investment. Paradoxically, numerical control has been slow to enter into the missile field, and tracer controlled lathes still predominate.

The missile industry is becoming more competitive as newcomers enter it, and the larger aircraft companies convert their facilities in an effort to capture missile contracts. Development work in rocket, nuclear, and ram type engines calls for the machining of new alloys, and most of the first parts are turned from bar-stock. To keep abreast of these developments, machinability programs are being established for the purpose of obtaining practical cutting data on these new materials.

Unit Cuts Fragile Materials

**by Industrial Division
S. S. White Dental Mfg. Co.**

NEW YORK—Gas-propelled to supersonic speeds through a small, precise nozzle, finely graded abrasive particles produce a cool, shockless cutting action. There is no contact between the tool and the work. What little heat produced is immediately removed by the propellant gas. A high order of accuracy is possible because the stream is precisely controlled.

It has successfully performed delicate operations on germanium, silicon, mica, glass, ceramics, alloy steels: etching lines, cleaning metallic smears from ceramics, matting and abrading, and deburring precision metals parts.

The Airbrasive Cutting Unit never touches the work. There is no chatter, no vibration, and no pressure. This makes it possible to cut fragile materials with complete safety and freedom from breakage. Both hand pieces and nozzle tip holders that can be rigged in fixtures are available. A wide range of cuts can be made. The same tool can cut a line as fine as .008″ or frost a large area.

Several nozzles with various shapes and sizes of orifice are available. An .006″ .060″ rectangular orifice will produce a minimum cut of .008″. Even narrower cuts can be made with nozzles available on special order.

Excellent abrading results are obtained from the process. It is valuable in the removal of surface deposits: metallic smears on ceramics, oxides on metals, etc., especially from parts too delicate to stand manual scraping or power grinding.

Skull Casting Holds Promise

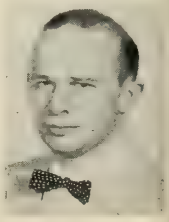
by A. E. LaMarche

PITTSBURGH—Skull casting exhibits all of the advantages of vacuum-arc melting, producing a clearer, less gaseous metal with attendant improved properties.

The skull casting process is particularly adaptable to metals such as titanium, zirconium, molybdenum, and tungsten—which react rapidly with atmospheric gases—as well as refractory (non-metallic) mold materials. Machined graphite is capable of yielding castings with a good surface and little contamination, although surface contamination is still in the order of 0.050″.

The skull melting and casting method also prevents contamination from refractory crucibles and can obtain ultrahigh temperatures needed for melting and refining by outgassing of the materials being melted.

A. E. LaMarche is a project engineer, Refractory Metals Section, Westinghouse Electric Corporation.



A water-cooled copper cylinder or chalice is commonly used in skull furnaces as the crucible or "melting pot" and can contain the melt if either a consumable or nonconsumable mode of melting is used. Since there is no crucible contamination in melting, the reactive and refractory metals can be cast and retention of the basic properties of the elements or alloys can be maintained in the solid state.

This newest of casting methods has been used recently to form a rocket nozzle casting weighing 62 pounds for **Aerojet-General Corp.** from the 50% molybdenum-50% tungsten alloy.

Heliarc Welding Increasing

by G. W. Oyler

NEWARK, N.J.—One of the leading metalworking advances of recent years has been the development of inert-gas shielded arc welding.

New metals and alloys, unheard of only a few years ago, have become the backbone of our national defense program. Military requirements hastened the use of these metals, but without the welding processes to fabricate them, much of U.S. military might would still be on the drawing boards.

Heliarc welding uses a virtually non-consumable tungsten electrode, and welds by fusion of the base metal. A filler wire may be fed into the weld puddle if additional metal is desired. Sigma welding uses a continuously driven wire electrode and welds by fusion of the base metal, with filler metal being added automatically as the consumable electrode melts off in the arc. Heliarc welding is primarily used on thin sheets under 1/8" thick, while Sigma welding is suited for thicknesses greater than 0.050." A space capsule fabricated with Heliarc or Sigma welding is essentially a single piece of metal, and will behave as such in outer space.

Heliarc argon-shielded welding was originally developed to improve welding of magnesium in the aircraft industry. It has since proven suitable for so many metals that it is now used in welding development work. To determine the weldability of such new metals as niobium, tantalum, uranium, vanadium and molybdenum, we carry out initial tests using Heliarc welding, with argon, helium, or mixtures of both for shielding. Some of the more reactive materials, such as zirconium alloys and hafnium, must be tested inside an inert-atmosphere chamber.

Titanium is extremely reactive at welding temperatures and sensitive to embrittlement by small amounts of some impurities. To adequately shield the puddle and surrounding weld area, an argon trailing shield is used in addition to the regular shielding cup.

G. W. Oyler heads the Laboratory Division, Electric Welding Department, Newark Development Laboratory of the Linde Co. Division of Union Carbide Corp.

• **Rigid standards**—Argon-shielded arc spot welding has solved many problems in missile fabrication. The confined spaces and low weight limits of guided missiles require fabricating with considerable spot welding. Depending upon material thickness, spot weld shear strengths must be between 200 and 5000 lb. per weld. Often these welds can be made from only one side of the joint. Both Heliarc and Sigma spot welding meet these rigid shear strengths.

A recent major breakthrough in tungsten-arc welding circuitry is the pilot arc. The electrode is kept hot and ready to fire at all times, and the pilot arc provides an ionized gas path as the torch approaches the workpiece, for instantly reliable starting. The arc replaces continuously troublesome high-frequency power.

The high-speed welding of extremely thin sheets of metal is now possible with short-arc welding. A new development of Sigma welding, the short arc process short circuits from 100 to 200 times per second, pinpoints the arc heat and produces a small "cold" puddle for welding of thin materials in the 0.020" to 0.100" thickness range without the addition of excessive filler metal.

Fusion Weld Must for Joints

by J. H. Berryman

NEW YORK—The design and fabrication problems inherent in space ship construction present many unique and peculiar problems. Only by fusion welding is it possible to make structural joints that possess the physical, corrosion-resistant, thermal-conducting properties necessary to successful space ship construction.

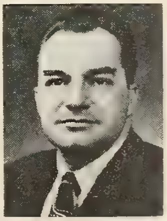
Outlined below are the major missile joint requirements and welded joint properties that can be evaluated to show the suitability of the welding process in missile fabrication.

• **Physical joint properties**—With few exceptions, welded joint efficiency in almost all structural metals and alloys is 100%. This means that a welded butt joint of this efficiency behaves under external load, corrosive conditions, and thermo-dynamic friction as though it were parent material.

• **Thermal joint properties**—A unique requirement of space vehicle fabrication is that the heat transfer across any joint is a vitally important factor. A butt-welded joint using a 100% cross section will have heat transfer across the joint equivalent to the parent material and is therefore preferable to any lap-type joint.

• **Corrosion joint properties**—A welded butt joint having no faying surface as a corrosion focal point or area, and which can be made using only fused parent metal or necessary fill metal selected from many desirable non-corrosive metals, is superior to other joint geometry and joining processes.

J. H. Berryman is general sales manager in the Special Products Department, Air Reduction Sales Co.



• **Availability of equipment**—Welding processes and equipment to weld various type joints, either manually or automatically, in a very wide variety of metals, is readily available to meet specified joint requirements. It should be pointed out here that machine or automatically welded joints are preferable in this area to manual welds.

• **Limitation of processes**—The fusion welding process has proven itself exceedingly adaptable to new requirements and new alloys. Temperature ranges up to 30,000°F are now available in commercial equipment for fusing and joining metals and ceramics.

Development in the welding art is widespread and continuing. This produces major improvements and opens up new joining techniques in both metallic and non-metallic materials.

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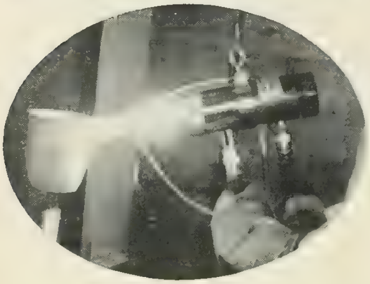

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How Honeycomb Panel Works

by Harold J. Black

NASHVILLE, TENN.—Honeycomb sandwich might be considered as a modern extension of the I beam section principle. For, to a much greater extent than in the I beam, honeycomb sandwich concentrates heavier bending materials at maximum distance from the neutral axis with an extremely lightweight cellular honeycomb core in between to stabilize the face sheets and carry out the shear stresses.

This structural arrangement is particularly efficient for design conditions involving panel bending, edge compression, rigidity, close adherence to contour under varying loads, and vibration environments.

For air vehicle speeds in the subsonic to Mach 2.0 range, operating temperatures are low enough to utilize bonded aluminum honeycomb quite effectively. As speed increases, structural designers are faced with two problems: (1) structural integrity at higher operating temperatures, and (2) ever greater emphasis on minimizing structural weight to reduce fuel requirements and increase payloads.

For sustained operation at temperatures of 450° to 650°F, and for short time operation up to perhaps 900°F, precipitation-hardening stainless steel alloys are in current use for brazed stainless steel honeycomb structures. Two of the most widely used alloys at present are the semi-austenitic alloys designed as 17-7 PH (17% Cr. -7% Ni) and PH 15-7 Mo (15% Cr.-7% Ni—2% Mo). These materials can be formed, brazed, and resistance—or fusion-welded fairly readily. Other alloys are also available for temperatures up to 1100°F, in the thin gages characteristic of lightweight structure.

Harold J. Black is director of Engineering at Avco Corp.'s Nashville Division.

Heat-treat Plus Cold Rolling

by Michael Watter

PHILADELPHIA—We instigated the development and application of high-strength alloys in which exceptional mechanical properties are obtained through cold rolling subsequent to heat treatment.

To exploit these materials requires special design concepts using spot and fusion welding. Structures of this type do not require final heat treatment, possess outstanding strength-to-weight ratio, and are dimensionally stable. At the present time structures whose thermal operating requirements fall into the range of room temperature to 1400°F can be fabricated using cold-reduced material.

The cold-reduced materials desirable for application from room temperature to 850°F are precipitation-hardening stainless steels, particularly cold-reduced AM 355. From 850°F to 1400°F, L605 answers requirements best. AM 355 is presently available in strength level of 300,000 psi, while a new experimental modification of this alloy, designated AM 357, has a strength level of about 360,000 psi at room temperature. L605 cold-rolled after heat treatment has the highest mechanical properties from about 900°F to 1400°F. From 1400°F to 1600°F René 41 shows up best. Beyond 1600°F, we prefer niobium because it can be formed and welded.

In addition, PH 15-7 Mo, A286 and Incaloy X were found suitable.

The two types of structural concepts of particular interest here are sequentially assembled rocket motor cases and structures employing welding steel sandwich or welded stringer-skin elements.

Michael Watter is on the research staff of the Budd Co.

In the sequentially assembled rocket case design, the assembly is composed of headers and cylindrical sections. The latter, due to the present limitations of the available width of 300,000 psi coils, do not exceed 36 inches. The individual subassemblies after being completely fabricated are fusion-welded together. Thus, while headers and cylindrical section material is at its maximum strength level, the joints remain ductile since the final assembly is not heat treated. The sequence of assembly is such that each individual subassembly and its attachment are sequentially checked, verified for pressure tightness and aligned, thus insuring dimensional accuracy and structural soundness.

The important feature of this type of design and method of fabrication is in its unsurpassed flexibility and economy. The size of the rocket or missile case does not depend on heat-treating facilities or elaborate metal forming machinery. The case can be made as large as desired and assembled where necessary without sacrificing its strength and efficiency.

The second structural concept of importance in missiles and space vehicles is the welded sandwich. The concept of welded sandwich was motivated by three major considerations: (1) to create a structural skin element which inherently made practical the eventual assembly of the whole structure; (2) to remove the temperature limitations that stem from the joining method; and (3) to keep the fabrication open to continuous control and inspection.

The two types of welded sandwich principally employed by us have double or single corrugated core with the apex of the corrugations having a very narrow flat or a radiused crown.

Structures of this type are not limited to steel or to resistance welding as the only method of assembly. We are developing a practical automatic welding machine using an inert gas tungsten electrode method. In addition to the materials mentioned, development work is being conducted with beta titanium, molybdenum and beryllium.

Defense Stockpile Hits Peak

by Heather MacKinnon

WASHINGTON—The United States is now at a peak of preparedness in its defense stockpile of strategic and critical materials, according to an Office of Civil and Defense Mobilization spokesman.

Of 73 materials listed as vital to the nation's defense, the OCDM program for FY 1960 calls for purchase of only three materials. Basic objectives in all other materials, assuring three years self-sufficiency in each in the event of a national emergency, have been fulfilled, under present and completed contracts.

The materials which have been authorized for open market purchase by the General Services Administration, are jewel bearings, used in instruments such as those in the guidance systems of rockets and missiles; small diamond dies, for forming fine wires used in rockets and missiles, and crysotile asbestos for insulation purposes.

Small quantities of materials already in the stockpile will be upgraded—converted to a more readily usable form—for emergency use. Companies holding contracts entered upon in FY '59 and still current are: **American Metal-Climax:** for the upgrading of electrolytic copper to oxygen-free copper and molybdenite to molybdic oxide; **The Wah Chang Corp.:** tungsten to tungsten carbide powder, and molybdenite to ferro-molybdenum; and the **Vanadium Corp.,** which is upgrading vanadium-oxide to ferro-vanadium. The total amount of these contracts will cost GSA approximately $4.5 million.

Two new contracts are in the process of negotiation. Additional amounts of tungsten carbide powder, upgraded from tungsten, is sought. It is useful for many high temperature applications. The other will be for more molybdic oxide from molybdenum, one use of which is in containers or reaction vessels requiring chemical inertness.

Within recent years, the number of strategic and critical materials listed by ODCM has been constantly increasing because of the many new processes and developments in industry. The programs named as making the most stringent demands upon the stockpile program are predominently in the missile/space industry. Studies are continually underway by ODCM to keep abreast of these new demands.

The volume of some materials in the stockpile, however, is not as large as in previous years because of increased efficiency of weapon and defense systems. For instance, the huge quantities of steel and aluminum needed to build the bomber and fighter planes of WWII are not necessary in the building of a missile defense system. Instead, the emphasis is continually on the search for new, higher grade metals.

Industry on the Move

Interstate Electronics Corp. and the A&E firm of **Benedict, Beckler and Associates** have teamed up to bid on missile range facilities and instrumentation projects . . . The A&E and electronic design groups of **Aerojet-General Corp.** are being combined into a new Aetron Division at Azusa, Calif. Aerojet also has opened a new $150,000 laboratory at Frederick, Md. . . . January is the starting date for construction of a $1.5-million administration building at the Newport Beach, Calif., facility of **Ford's Aeronutronic Division** . . . On steam—the **Linde Co.'s** 25,000-liter per month liquid hydrogen plant at Tonawanda, N.Y. . . . **Aeroquip Corp.** has completed a 30,000-square-foot plant expansion at Burbank, Calif. . . . **Dynamics Corp. of America** is doubling its quartz crystal production capacity at Carlisle, Pa. . . . **Reliability Engineering Associates** is now in a larger headquarters at Skokie, Ill. . . . Earth moving is under way for a headquarters of **Lockheed Electronics and Avionics Division Lead** at Newport Beach, Calif.

Forty-inch Forging Made Of Nickel-based Astrolloy

NORTH GRAFTON, MASS.—The **Wyman-Gordon Co.** says it has succeeded in producing a 40″ diameter, closed-die forging of the new nickel-based astrolloy.

Astrolloy is a high-temperature alloy for which a 160,000 psi ultimate tensile strength is claimed at 1400°F. In addition to nickel, it contains 15% cobalt, 15% chromium, 5% molybdenum, 4.3% aluminum, 3.5% titanium, 0.7% manganese and smaller amounts of copper, sulfur, iron, silicon and boron. The alloy was developed by **General Electric Co.**

Unique Radio Link Joins North American Divisions

LOS ANGELES—A new microwave radio link will give **North American Aviation** a combined commercial computing facility larger than any now existing at any one location. The link will tie together six large-scale **IBM** computers at Los Angeles headquarters with the Rocketdyne Division 39 miles away, as well as the Missile and Autonetics Divisions at Downey.

This is the first time data has been transmitted between computers without the use of a direct-wire link.

The system, which can handle 180,000 words per minute, makes the computer facilities instantly available to engineers in the detached divisions. Previously, tape data had to be hand-carried between NAA's outlying plants.

new development explained . . .

Explosions Form Missile Metal Parts

Assessing claims made that the technique that violates all rules of forming; tougher metals give better results; solids behave like fluids or plastics

by John S. Rinehart

GOLDEN, COLO.—The shaping of metals—compaction, forming, drawing and swedging—is a technology that contributes heavily to the fabrication of missiles and rockets. Any advance in this technology implies advance in missile and rocket technology.

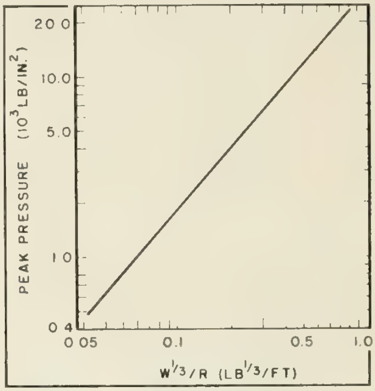
Recently, the introduction of metal forming using explosive charges has given rise to fabulous claims and it has been difficult for management and engineers alike to assess the true worth of this development.

What are the true facts? Does explosive forming violate all the rules for forming: The tougher the metal, the better the results? Under such loads do even the toughest metals behave strangely, acting more like fluids or plastics than solids?

In any such process, one is dealing with explosives, metals, and the nature of the coupling between the two. The source of energy is an explosive. There are two main types: High explosives, characterized by very high rates of reaction and high pressure; and deflagrating explosives or propellants, which burn more slowly and develop much lower pressures. The energy released on reaction is usually about 1,000 calories per gram whether the explosive detonates or burns.

In the case of high explosives, the pressure may be as high as 4,000,000 psi—at the surface of the explosive. A short distance away, pressure is much less but its duration much longer.

Propellants, when burned in the open, produce pressures no higher than a burning kitchen match. When confined, propellants can build up quite high pressures, which can be easily controlled, as in a gun, being usually limited to 40,000 to 50,000 psi.



PRESSURE produced in "water" by spherical TNT charges in explosive forming plotted against charge weight $^{1/3}$ distance.

• Microsecond measure—The sudden release of the energy of a high explosion takes place in a microsecond or so, the pressure building up in the same time; the explosion gases rapidly expand, dissipating energy, and the pressure drops suddenly, coming to zero in a few microseconds. The pressure generated by burning propellants takes several milliseconds to develop but, being confined, will be sustained for quite long times. Decrease in pressure comes about through cooling of the gaseous explosion products. Explosives forming groups into two situations:

One in which the explosive is detonated in intimate contact with the metal, such as in the hardening of steels, compaction of metal powders, splitting of ingots, and cutting operations. The other in which objects such as cups, rocket nozzles, missile noses and aircraft parts are sized or formed by drawing—using propellants or explosives detonated in air or in water at some distance from the worked piece.

When the explosive is placed in intimate contact with a metal and detonated, the stresses just inside the metal will instantaneously become exceedingly high. A transient stress disturbance is set up and transmitted through the metal, producting fracture, plastic flow, and other deformations, the exact nature of which will be strongly dependent upon the configuration of the metal-explosive system.

Even under these extreme pressure conditions, the metal is seldom converted to a fluid, exhibiting in general the properties of a quasi-elastic brittle material.

• Pounding pictures—The stratagem in metal forming is to turn to advantage specific patterns of failures. Thus, ingots may be split by simultaneously detonating explosive charges on opposite sides of the ingot; or internal scale on heating pipes may be removed by detonating an explosive charge on the exterior surface of the tube—dislodging the scale in the same way a picture is knocked down by pounding on the reverse side of the wall.

Generally, in explosive forming the explosive is not placed in intimate contact with the metal but is separated from the work-piece by water or some other fluid.

If the intervening medium is air, the peak pressure will be greatly reduced even though the distance between explosive and metal is quite small. A liquid such as water provides a much better coupling medium between explosive and metal than does air. Water, or any other liquid, has the effect of rounding off the pressure pulse. It reduces the peak pressure, while prolonging the time over which the pressure acts.

Several parameters must be considered in analyzing the action of the pressure pulse upon the work-piece. It is not entirely clear whether it is peak pressure, total impulse, or kinetic energy that is the most important physical parameter needed to describe the interaction between coupling medium and work-piece. Both peak pressure and total impulse are dependent upon the weight of the charge

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Dr. John S. Rinehart is director of the Mining Research Laboratory, Colorado School of Mines.

and its distance from the work-piece, both pressure and impulse changing only as the cube root of the charge weight. Peak pressure and impulse are more sensitive to distance than charge weight, varying inversely with its first power.

- **Pressure variation**—At equal distances away from an 8 lb. charge and a 2 lb. charge, the peak pressure produced by the 8 lb. charge will be only twice that produced by the 2 lb. charge, indicating that in explosive forming operations the size of the charge will not be particularly critical. In the accompanying diagram, peak pressure produced in water by spherical TNT charges is plotted against (charge weight) $^{1/3}$ (distance). Curves for other explosives will not be substantially different.

In conventional metal forming, the metal of the part that is to be formed must, at some time during the forming operation, be in contact with the forming die. The distribution of stress established by the die is exceedingly complex—almost impossible to describe—with many opportunities for the development of regions of high stress concentration which, in turn, can lead to fracturing in localized areas.

A dynamic stress field of the kind set up when an explosive is detonated in a liquid usually distributes itself more uniformly over the whole piece to be formed, penetrating into every crack, crevice, and corner so that the metal is pushed about uniformly. In effect, it is almost as if one were using a well lubricated die of ever changing shape, the shape continuously and instantaneously conforming to the shape of the metal part as it is being formed.

A typical explosive forming operation such as the sizing of a metal nose cone, 5′-to-6′ in diameter, 1″ thick piece might be carried out as follows: The partially formed nose cone, dimensionally within several thousandths of final tolerance, is placed in a large female die. The cone is then filled with water and one or more small explosive charges, perhaps an ounce each, are suspended in the water at appropriate locations, the charges then being detonated electrically from afar. The charges explode, pushing the water ahead of them against the metal, the metal drawing itself out so as to fill the die completely.

- **Slow motion**—In other cases, water is placed in a polyethylene bag, with female dies sometimes being used, but in other instances the metal being allowed to form itself freely, taking whatever shape the pressure of the pulse dictates. The movement of the metal is not particularly rapid, being at most 100 to 200 ft/sec, a velocity below the critical impact velocity of most metals.

When propellants are used, the system must be gas tight, for the pressure must be allowed to build up relatively slowly. A typical operation could be the converting of a thin walled round tube into one of square cross section. The tube would be placed in a heavy walled container of square cross section suitably equipped with some means, such as a primed shot gun shell, for igniting a small amount of propellant powder. On ignition, pressure builds up, pushing the round tube outward so as to come up snugly against the square interior of the die.

In spite of much propaganda to the contrary, metals as a rule have less ductility when deformed rapidly than when deformed slowly, just as tar will stretch to great lengths when pulled slowly but will break in a brittle manner when struck a sharp blow. A few metals, notably the high manganese and high nickel steels and certain aluminum alloys, show as much ductility at high rates of strain as at low. Copper and certain other nickel steel alloys manifest increased ductility when strained rapidly.

There is a paucity of data on the

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effect of rate of straining on the ductility of metals. But, the physical properties of metals at low temperatures have been extensively investigated, and many analogies can be drawn—both behavior patterns being dependent upon activation energies in much the same way. In none of these applications is the metal subjected to such pressures that it is converted to a fluid.

Metal forming using explosive charges is in its infancy. Its potential is now being evaluated with great intensity of effort in government, industrial and academic scientific communities. It is still too early to make a realistic appraisal of the engineering potentialities of explosive forming.

Method Can Increase Deforming Ability

by the du Pont Explosives Department

WILMINGTON, DEL.—The use of extremely high pressures generated by the detonation of high explosives appears to be uniquely suited for forming many metal parts not now easily made by more conventional means.

In some cases, particularly with some of the newer alloys, it has been found that the high forming rates produced by such intense pressures permit a significant increase in the extent to which materials may be deformed. Of great practical importance also has been the discovery that practically no "springback" is associated with the explosive deformation of metal sheets. There have been indications also that properties are enhanced additionally by the explosive sizing operation.

Explosive forming is still in its infancy. Present indications do not suggest it will supplant high-speed, repetitive-press forming, but it does appear attractive in areas where a limited number of parts are desired and tool amortization represents a large share of production costs. It is potentially capable of making as a unit objects which are now formed in several parts and later assembled.

In free-forming, material is allowed to form unrestrained into free space. Shapes were produced for the **Haynes-Stellite Co.,** Kokomo, Ind., using some of their high-temperature alloys. In this instance, the flat blank was retained on a draw ring with no die cavity beneath. When the explosive charge was detonated in a fluid medium above the blank the metal flowed into a dished configuration. Variations in shape from generally hemispherical to almost conical were found to be attainable, by varying not only the size, shape or location of the explosive charge but also certain physical aspects of the tooling. Similar shapes were formed by this technique from aluminum and stainless steel.

Considerable work has been done in forming a variety of shapes and sizes of dished heads. The largest head produced successfully to date was a railroad tank car end 8′ in diameter and 3/16″ thick for the **Graver Tank & Manufacturing Co.,** East Chicago, Ind.

Great dimensional accuracy in shapes formed from conventional materials and particularly the newer high-temperature, high-strength metals and alloys also is of paramount interest. Explosive forming, for instance, has been used to shape a scaled-down rocket motor venturi, a corrugated cylinder, and a flange for a duct-work joint.

Successes also have been recorded in producing corrugated shapes from flat blanks. Deep and wide grooves have been created explosively with high dimensional accuracy in 0.030″ 302 stainless steel. Deep and sharp spiral grooves also were formed satisfactorily for a fuel filter disc.

Process Might Be Used in Space Work

by Vasil Philipchuk

WEST HANOVER, MASS.—The art of fabricating certain materials for application to missile, rocket, and space vehicle parts through explosive forming is being accelerated. It is conceivable that the explosive process will be used in space, should fabrication techniques be required once the outer planets are reached—weight will constitute the greatest advantage when explosives are used as part of a process in space.

Currently we use explosive fabricating techniques for forming, forging, welding, locking and bonding, embossing, and compaction. Variables entering the process for particular parts are explosive type, explosive geometry, medium (for force transmittal) die material, die design, and set-up technique.

The state-of-the-art remains fairly new in the overall fabrication picture. Individual parts that are being produced and shipped are more advanced in the art, but rarely do two different parts get the same fabricating technique. Thicknesses of metals used in parts fabrication have ranged from .006 to 4.0 inches; weight of the parts has varied from a few grams to over two tons.

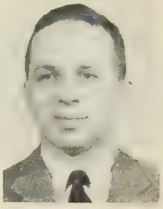
The following metals, alloys, or semimetals have been or are presently being tested under explosive forces for end applications at **National Northern:**

Copper alloys, aluminum alloys, stainless steel alloys, magnesium alloys, titanium alloys, nickel alloys, carbon steels, tool steels, beryllium, molybdenum, tungsten, tantalum, niobium, uranium, boron and zircalloy—2.

Explosive fabrication has a number of advantages: it reduces the number of operations; it requires no large capital equipment; it produces better tolerances in parts and imparts better physical properties to the finished part; it is the only known method for obtaining parts of certain designs, and facilities for its use can be set up with comparative speed and convenience.

Most parts will continue to be made more cheaply by conventional methods; explosive forming cannot compete with stamping machines or rotary process on an assembly line. Explosives always have and always will require the utmost respect in manufacturing, handling and detonation.

The Space Age has brought a demand for new metals and new designs. The new parts involved present problems to the conventional fabricator, and it is here that explosive forming can sometimes assist.



Vasil Philipchuk is Manager, Special Projects Division, of the National Northern Division, American Potash & Chemical Corp.

Medaris Would Cut 'Marginal' Projects

by William J. Coughlin

LOS ANGELES—Many current space projects should be dropped so the nation can concentrate its funding and technical effort on the few most important ones, Maj. Gen. John B. Medaris, retiring commander of the Army Ordnance Missile Command, told a press conference here.

Medaris declined to name any candidates to be scratched but did cite two projects which he believed should receive fullest support:

- *Saturn.* This is the first vehicle which will give the U.S. the possibility of doing a space job without straining technical capability to the maximum.
- *Nike-Zeus.* The nation must have confidence in this defensive project and move accordingly, despite the cost. "I have every reason to believe it will be successful," he said.

"For the first time in history," the general said, "there are more things which can be done in military and scientific endeavor than any nation in its right mind can possibly do."

The Army missile expert said the U.S. has two alternatives to do many things partially or a few things well. "Throughout my career I have favored doing fewer things and doing them better," he commented.

Medaris said the U.S. space program currently is pushing every vehicle to its limits, leaving no margin for reliability. *Saturn* will be the first in which work can be programmed on the basis of reliability and not over-sophistication.

"I definitely feel we should push *Saturn,*" he said. *"Nova* as a follow-on also is important, but first we should push *Saturn."* He noted that the first full-scale static test of all eight engines in the clustered *Saturn* booster, capable of putting 25 tons into earth orbit, will be made late next spring. The *Nova* cluster, he said, will have a capability of up to 10-million pounds thrust.

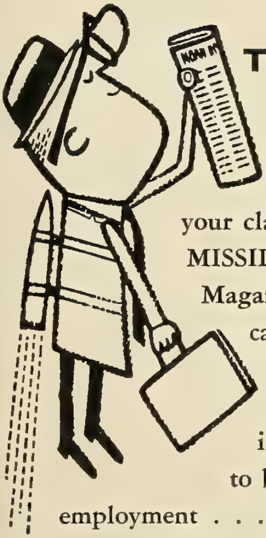
• **Pound-foolish?**—Although refusing to suggest publicly which projects should be dropped, Medaris said: "The things I object to are the things that are a marginal improvement. It costs almost as much to engineer a small step forward. And engineering costs are the major cost."

Questioned on the award of the *Dyna-Soar* contract, in which the Air Force will retain the role of weapon system manager, Medaris said: "My own feelings are that a package should be kept together in the hands of someone who does the major portion of the work. A government agency should be used only if it has the resources to do the major part of the work. This was the case of ABMA."

• **Takes two to race**—Primary decision of whether the U.S. is or is not in a space race with the Russians has yet to be made, the general said.

"The people themselves have to make up their mind—are we in a race or are we not, and are we prepared to make the sacrifice?" he said. "So far, I've seen no evidence of a solid resolution to compete in a race."

Concerning the controversial decision to put U.S. space programs in the hands of the National Aeronautics and Space Administration, Medaris said he believed the effort must be brought under a single management in a mutually supporting, non-competitive effort. But he added: "I am loathe to agree this (NASA) is the final best agency for the purpose."



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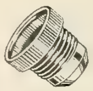
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Officials Play Down Space Race at ARS

By **James Baar**

WASHINGTON—The 14th annual meeting of the American Rocket Society here Nov. 16-20 operated most of the time in a low key.

Government officials generally played down the lopsided East-West space "race," despite the feeling of many delegates that the need for revamping the U.S. space program is urgent. And a great number of the technical papers presented appeared to be little more than variations on popular themes.

Dr. William H. Pickering, director of NASA's Jet Propulsion Laboratory, charged that U.S. space efforts are too feeble to overtake Russia in space.

But Dr. Wernher von Braun, technical director of the Army Ballistic Missile Agency, was reduced by government pressure to talking about children and rocketry. And Brig. Gen. Homer Boushey, Air Force Advanced Technology Chief, no more than hinted broadly that contrary to the opinion of some top government officials the military has an important role to play in space.

More pointed comments by scientists and officials attending the meeting were made privately in hotel rooms and lounges.

- **Calm Russians**—A high-ranking Soviet delegation headed by Dr. Leonid I. Sedov, chairman of the Soviet Academy of Science's Interplanetary Travel Commission, sat through it all, politely answering some questions and politely ducking others.

Besides Sedov, the five-man delegation—first Russian group to present papers at an ARS meeting—included Prof. A. A. Blagonravov, a member of the Soviet Academy's Praesidium, and Prof. Valerian I. Krassovsky, chief of the Academy's Institute of Atmospheric Physics.

All declined to disclose any details of future Soviet space plans. But they appeared quietly satisfied.

Some of the more noteworthy papers presented during the four-day meeting:

- Dr. John Gustavson of **Grand Central Rocket** proposed the development of a 2.4-million-pound-thrust solid booster. He said six of them could be clustered to provide a gigantic solid booster yielding 14.4 million pounds of thrust. He named the smaller the *Cronus;* the bigger one the *Novus.*
- Dr. John C. Moise of **Aerojet-General** reported the development of a liquid hydrogen pump which would make possible construction of a 500,000-pound-thrust liquid hydrogen-LOX engine. He said the pump was tested this month in a 100,000-pound-thrust engine.
- Sedov reported on details of the orbits of the Soviet "Cosmic Rockets" and discussed the selection of sites, trajectories and times for earth-to-moon rocket launchings.
- Blagonravov discussed the isolation of instrument packages from rocket vehicles, temperature regulation in satellites and the orientation of satellites in space. Krassovsky discussed sodium vapor experiments, radiation measurements, cosmic rays, spectrometric determination of atmospheric ions and ionization and magnetic manometers.
- Four scientists from **Space Labs, Inc.,** reported that they successfully imbedded a two-ounce radio transmitter in the body of a space dog named Orbit. The transmitter was connected to the dog's heart so that it could transmit electro-cardiograms to monitoring stations from space.
- Irvin H. Schroder and John G. Chubbuck of the **Applied Physics Laboratory** said an orbiting astronomical telescope could be designed and placed in orbit within the next few years. The telescope would have a primary mirror 36 inches in diameter and a focal length of 8 to 10 feet.
- Rep. Peter W. Rodino Jr. (D-N.J.) warned that the world must find a means now to ensure international cooperation in space. He said "it will mean our final disaster if we permit space to become a new battlefield." He joined other delegates in calling for international agreements on space law.
- **Atomic progress**—AEC Chairman John A. McCone told ARS delegates at the annual Awards Night Dinner that first experiments in Project *Rover* already confirm the theories concerning the very high specific impulse attainable with nuclear energy."

"It is my judgment that this development will complement the chemical rocket engines and that the two in combination will provide the means for lifting large and heavy payloads in orbit," he said.

ARS elected Dr. Howard S. Siefert, **STL** special assistant for professional development, as president succeeding Air Force Col. John P. Stapp. Dr. Harold W. Ritchey, vice president of **Thiokol** was elected vice president.

ARS elected five directors for the three-year terms.

Exhibits included the first public showing of a **Martin** *Titan.* It was set up in front of the Sheraton-Park Hotel.

According to a possibly apocryphal story that made the rounds of convention sessions, Sedov asked when shown the *Titan:* "What is the scale?"

• • •

As a special service M/R staff members have prepared a number of abstracts of papers presented at the ARS meeting. Some follow, more will be published next week.

ARPA Shifts Space Projects

WASHINGTON—ARPA has officially transferred three major space projects—*Samos, Midas* and *Discoverer*—to the Air Force and a fourth—the huge *Saturn* program—to NASA.

The *Saturn* transfer is on an interim basis pending congressional approval. Meantime, many strings to the program are being retained in Pentagon hands.

The transfer of *Samos, Midas* and *Saturn* was expected. The *Discoverer* transfer was a surprise.

The four programs make up more than half of ARPA's FY 1960 budget: *Samos,* the reconnaissance satellite, had about $120 million; *Discoverer,* the satellite experimental program, about $100 million; *Midas,* the early-warning satellite, about $35 million; *Saturn,* the 1.5-million-pound-thrust clustered booster and space vehicle, about $70 million.

Samos, Midas and *Discoverer* funds are being transferred to the Air Force. ARPA will continue to administer *Saturn* under technical direction of NASA and a *Saturn* Committee including representatives of NASA, ARPA, Air Force and Army Ballistic Missiles Agency.

Solid Rocket Technology

On the Use of Solid Propellants for Multimillion-pound Boosters, John Gustavson, Advanced Concepts Office, Grand Central Rocket Co., Redlands, Calif.

Solid and liquid space vehicle launchers are compared on the basis of the well-known velocity increment equation. Two solid-propellant launchers are presented of 2.4 and 14.4 million-pound initial thrust capable of launching 26,000 and 150,000 pounds of payload respectively into a 300-n.mi. satellite orbit. The merits of the suggested space boosters are discussed, including the new Nitrasol solid propellant, the lightweight plastic nozzle, control problems, continuous mixing and booster cost. It is pointed out that although solid propellant chemicals are more expensive than liquid ones, the handling and logistics problems will make solids available at a lower cost in the loaded vehicle. Also, since the solid system consists of fewer components than the liquid, the development time and cost is substantially less, and greater reliability is attained (ARS 1012-59)

Design Considerations for Spiralloy Glass-reinforced Filament-wound Structures as Rocket Inert Parts, A. H. Kitzmiller, Jr., C. C. DeHaven and R. E. Young, Hercules Powder Co., Cumberland, Md., and Rocky Hill, N.J.

SPIRALLOY structures of oriented continuous glass filaments and resins are presently being used in successful series of Allegany Ballistics Laboratory solid propellant rockets. These reinforced plastics offer a most attractive strength/weight ratio and a practical and economic rocket structure. This report describes some of the basic factors which affect the design and fabrication of SPIRALLOY pressure vessels; e. g., the type and amount of resin; the winding angle, pattern and tension; and the contour and winding angle best suited to integrally wound end closures. The physical properties are given and the effects of material, design and fabrication upon these characteristics are discussed. (ARS 983-59)

Communications Equipment

Abrupt Telemetry Signal Strength Fades in Powered Flight on *WS107A* Re-entry Vehicles, Edward Niemann, Jr., Missile and Space Vehicle Dept., General Electric Co., Philadelphia.

Surveys telemetry data obtained during Atlas re-entry tests and shows cause of signal fades to be combination of shock wave and corona effects. (ARS 978-59)

Decommutation of 100% Duty Cycle Telemetered Signals, M. G. Pawley and E. D. Heberling, U.S. Naval Ordnance Laboratory, Corona, Calif.

Describes new commutator designed for 100% duty cycle commutated signals. Unit also provides improved performance with standard PAM and PDM commutated signals. Emphasizes details of synchronization technique. (ARS 979-59)

An Analog and Digital Airborne Data Acquisition System, James M. Walter, Jr., and Donald H. Ellis, Radiation, Inc., Melbourne, Fla.

Describes flexible transistorized analog-digital data acquisition system built for GE test facility at Edwards AFB. Includes details of low-level gate circuit, programming, accumulating, and coding techniques. (ARS 980-59)

The Effect of Different Types of Video Filters on PDM/FM Radio Telemetry, Myron Nichols and Arthur Bublitz, University of Michigan, Ann Arbor.

Extends previous analyses of filter comparison and corrects method of optimization described by Nichols and Ranch in their book "Radio Telemetry." (ARS 981-59)

Ion Propulsion

Experimental Studies with Small Scale Ion Motors, R. C. Speiser, Carl R. Dulgeroff and A. T. Forrester, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

Presents results of cesium surface ionization ion sources in ion motor configurations. (ARS 926-59)

Physics of the Ion Thurst System, Raymond Fox, University of California Lawrence Radiation Laboratory, Livermore, Calif.

Describes study of source, acceleration, and neutralization of ions for space propulsion applications. Summarizes most important problems and solutions. (ARS 927-59)

Ion Propulsion Systems: Experimental Studies, Sam Maiditch, R. M. Worlock, D. Zuccaro, D. Barker, M. P. Ernstene, L. R. Gallagher and J. Mullins, Electro-Optical Systems, Inc., Pasadena, Calif.

Gives comprehensive survey of problems and solutions in development of ion propulsion. Covers ion sources, accelerators, neutralization. (ARS 928-59)

Thurst Multiplications by Successive Acceleration in Electrostatic Ion Propulsion Systems, David B. Langmuir, Thompson Ramo Wooldridge, Inc., Los Angeles, Calif., and B. R. Cooper, University of California, Berkeley.

Presents theoretical considerations of properties of idealized electrostatic propulsion systems in which ions are transmitted without loss through equipotential accelerating planes.

Guidance

An Orbiting Astronomical Telescope Design Study, Irvin H. Schroader, John G. Chubbuck, Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.

The authors describe basic elements of a satellite observatory: structure, optics and control, command, and telemeter system plus associated ground station. They note problems to be solved before observatory can be placed in orbit. (ARS 912-59)

Midcourse Guidance Rekuirements for Mars and Venus Probes, Friend H. Kierstead, Jr., Goodyear Aircraft Corp., Akron, Ohio.

This paper discusses midcourse accuracy requirements for typical Mars and Venus flights, presents numerical results obtained for proposed flights with various guidance techniques, and compares capabilities of the different systems. (ARS 914-59)

The Rotating Pendulum Accelerometer, Samuel Schalkowsky and Henry F. Blazek, Ford Instruments Co., Long Island City, N.Y.

The authors describe basic features of a new class of precision accelerometers particularly adapted to measurement of slowly varying low-level accelerations. They compare this with conventional techniques. (ARS 915-59)

Physics of the Atmosphere and Space

Photographic Studies of Horizon Patterns from High Altitudes, D. Hoffleit and T. R. Bechtol, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

The authors describe equipment developed for the study of the horizon from high altitudes. Horizon cameras, either balloon- or rocket-carried, are described. Photos obtained are analyzed and a summary of results indicates the usefulness of photometric horizons and the even greater value for studies of atmospheric structure. (ARS 917-59)

Ionospheric Structure Above Fort Churchill, Canada, from Faraday Rotation Measurements, Raymond E. Prenett, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

During the International Geophysical Year, a number of sounding rockets were fired into the ionosphere above Fort Churchill. By determining the Faraday rotation of the 76.06-mc DOVAP tracking signal transmitted from the rockets, the integrated electron content was computed. Evaluated data from two flights are presented. (ARS 918-59)

Convection Currents in the Earth's Mantle, A. L. Licht, National Aeronautics and Space Administration, Washington, D.C.

Characteristics of a hypothetical convection current in the earth's mantle have been determined by using recent measurements of the third zonal harmonic component of the earth's gravitational potential. The calculations are discussed and results are analyzed and evaluated by the author. (ARS 941-59)

Plasma Propulsion

The Plasma Jet as an Electric Propulsion System for Space Application, Gerhard Heller, Army Ballistic Missile Agency, Redstone Arsenal, Ala.

Describes a plasma jet-propelled moon supply mission. Propulsion system has a thrust of 70 pounds and an I_{sp} of 1000 sec. (ARS 1004-59)

NASA Research on Plasma Accelerators for Space Propulsion, W. Moeckel and W. Rayle, Lewis Research Center, National Aeronautics and Space Administration, Cleveland.

Describes current NASA research and future plans. Concludes that plasma accelerators are still too poorly understood to determine their place in space propulsion. (ARS 1005-59)

Magnetohydrodynamic Flow Experiments of a Steady State Nature, V. H. Blackman, MHD Research, Inc., Newport Beach, Calif.

Describes the facility set up in an effort to combine the steady-state flow characteristics of a wind tunnel with the high gas temperature capability of a shock tube. (ARS 1007-59)

Experimental Results with a Collinear Electrode Plasma Accelerator and a Comparison with Ion Accelerators, S. W. Kash, and W. L. Starr, Lockheed Aircraft Corp., Sunnyvale, Calif.

Presents results obtained from a collinear electrode plasma accelerator. Specific impulse greater than 2000 sec. obtained and up to 6000 are indicated. Efficiency of operation is greater than 30%; 50% should be possible. (ARS 1008-59)

On Magnetohydrodynamic Propulsion, Arthur Kantrowitz and G. Sargent Janes, Avco-Everett Research Laboratory, Everett, Mass.

Discusses properties of plasma accelerators using electrodes considered as circuit elements. Presents theorem relating minimum instantaneous power, efficiency, and specific impulse. (ARS 1009-59)

Plasma Propulsion, Gordon L. Cann and Adriano C. Ducati, Giannini Plasmadyne Corp., Pasadena, Calif.

Discusses possible application of arc jet propulsion. Concludes that the arc jet is competitive with chemical and ion propulsion systems only if propellant can be carried as a liquid or solid. (ARS 1010-59)

Miniaturization Advances

Molecular Electronics, Gene Strull, Semiconductor Div., Westinghouse Electric Co., Baltimore.

The author defines molecular electronics as "the complete merger of function and material." By simile he carries the definition further to more completely describe this concept of functional solid-state circuitry. The author provides a detailed description of two applications of molectronics; a light telemetry system and a pulse generator. Each consists only of a power supply load, and a single semiconductor wafer having a volume of 0.001 in 3. (ARS 1001-59)

Data Recovery—The Heart of the Flight Instrumentation Problem, P. A. Lathrop, and P. B. Aller, Missile and Space Vehicle Dept., General Electric Co., Philadelphia.

The need for more accurate, sophisticated and reliable flight instrumentation steadily increases, according to the authors. The problem is greatly magnified in unmanned space vehicles, missiles or satellites. Major considerations in the successful instrumentation design of two types of data recovery capsules are described in detail: free-fall and drag-retardation types. (ARS No. 1003-59)

Microminiaturization of Space Computer, Edward Keonjian, Missile Guidance Dept., American Bosch Army Corp., Garden City, N.Y.

The application of microminiaturization techniques to computer design can result in a vastly reduced (10:1) total volume and a significant increase in system reliability, states the author. Technique reduces total number of parts and corresponding number of soldered joints which previously were serious sources of trouble. Use of these techniques in Arma's Adder computer is described in detail. (ARS No. 998-59)

The Macro-Module Program, Stanley Schneider, Research Center, Burroughs Corp., Paoli, Penna.

The author describes the concept of the Macro-module construction for digital data processors for achieving compact, high-density modules. Method reduces vast number of required system intraconnections. Basic philosophy involves consideration of 2-dimensional circuits and a 3-dimensional system. Subsystem fabrication is described in detail. (ARS No. 999-59)

Far Space Communications

Some Recent Developments in Communications Equipments for Missile and Space Programs, Daniel Hochman, Lockheed Missiles and Space Div., Sunnyvale, Calif.

Describes recent developments at Lockheed Missile and Space Division. Covers PAM-FM telemetry links and solar-powered telemeter beacon. (ARS 961-59)

Re-entry H. F. Transmission Experiment, Jack B. Duryea, Edward F. Paski, and William L. Aseniero, Missile and Space Vehicle Dept., General Electric Co., Philadelphia.

Reviews current experimental program on feasibility of transmitting data through plasma sheath during hypersonic re-entry. Frequencies used during inconclusive tests were 3-30 mc. (ARS 962-59)

Support Equipment

Support Equipment Designers Look at the Moon, M. J. Neder, T. E. Walsh, Aerojet-General Corp., Azusa, Calif.

Environmental factors—high vacuum, solar and cosmic radiation, meteors, extreme temperature ranges and the possibility the moon is covered with a deep layer of dust —pose a whole new set of problems in developing support equipment for a manned lunar landing and return. The authors also discuss thermoelectric generation of power to support a moon operation. (ARS 994-59)

Ion Engine Test Laboratory Planning, R. O. Dietz, Arnold Engineering Development Center, Tullahoma, Tenn.

Ion and chemical rockets are compared for transferring a satellite from 150-mile altitude orbit to a 24-hour orbit; author also describes laboratory requirements for full-scale development testing of ion engine design for satellite propulsion. (ARS 995-59)

Altitude Facility Rocket Testing, I. C. Lightner, ARO Inc., Tullahoma, Tenn.

Presentation of performance capabilities of engine test facility at Arnold Engineering Development Center and examples (including "chuffing") of phenomena observed during altitude tests. (ARS 996-59)

Missile and GSE Transportation Environment, M. T. Kirkenmeier, Chrysler Missile Division, Detroit.

Discussion of shock and vibration factors encountered in the transport of missiles by rail, highway and overland. (ARS 993-59)

Are We Ready?—Developing Operational Weapon System Launch Control and Checkout Equipment, Leonard Chevlin, The Martin Co., Denver.

Operational and reliability requirements of *Titan* ground-based system are set forth by the author. (ARS 997-59)

Available Power Systems for Space Vehicles, Harris J. Howard, and Robert W. McJones, Vickers, Inc., Torrance, Calif.

Weight and performance data are presented for available and projected power systems, with results of some recent development programs included. Systems are compared against power requirements for non-recoverable solid rocket boosters, recoverable re-entry vehicles, and long-duration space vehicles. (ARS 1032-59)

The Advanced Stirling Engine for Space Power, H. W. Welsh, E. A. Poste and R. B. Wright, Allison Div., General Motors Corp., Indianapolis, Ind.

Presents results of studies on thermomechanical power systems. Analysis shows that high efficiency (over 30%) and operational characteristics of the advanced Stirling engine meet requirements for space power and result in significantly low system weight. (ARS 1033-59)

Thermoelectric Cooling, Irving Sochard, Diamond Ordnance Fuze Laboratory, Washington, D.C.

Described theory and application of Peltier refrigeration. (ARS 1034-59)

Propellant Type Open Cycle Secondary Power Systems for Manned Space Vehicles, Antonio Orsini, Walter Kidde & Co., Inc., Belleville, N.J.

Discusses use of both mono- and bipropellant systems for space power generation. Author deals with open-loop systems only and notes that comparable closed-loop data does not exist at present. (ARS 1035-59)

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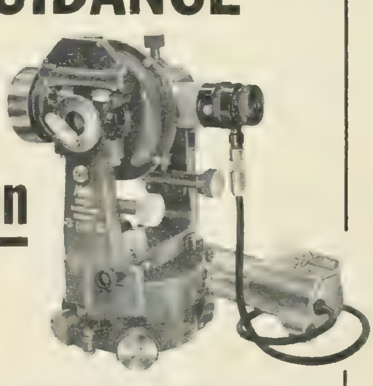

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Safety and Reliability

Propulsion Aspects of the Piloted Space Flight Safety Program, James H. Madden, Aerojet-General Corporation, Azusa, Calif.

Present propulsion system reliability and safety prediction and achievement methods are examined and predictions made as to anticipated future growth of reliability and safety. Interrelationship between reliability and safety is considered and compatibility between requirements for these objectives is discussed. The use of multi-engine clusters and redundancy theory are introduced as the primary methods by which adequate space vehicle reliability and safety may be attained. Special equipment requirements for piloted vehicle applications are considered. Discussion of modifications to present safety requirements includes the need therefore as delineated by state-of-the-art status as well as trends in propulsion system development. The capability of present liquid rocket engines to provide for immediate manned space flight operations is treated.

Evaluating Crew Safety for Rocket-Powered Manned Space Vehicles, William L. Hadley, Bell Aircraft Corporation, Buffalo, N.Y.

The author discusses the steps to be followed in the prediction of crew safety and shows examples of the methods of prediction which have been successfully applied to determine the adequacy of safety provisions in manned space vehicles.

Performance and Reliability of Attitude Control Rocket Systems, O. S. Williams, Thiokol Chemical Corporation, Denville, N.J.

The author investigates the performance and reliability of three basic types of attitude control systems, stored gas, monopropellant and bipropellant, and their response characteristics. Considerations are given to system optimization, to improved performance and the effects of these improvements on overall reliability. A correlation between performance and reliability will be shown, and the need for further development in both areas will be discussed.

Effects of Manned Payloads on Booster Engine Requirements in Regard to Safety and Reliability, J. P. Hynds, C. J. Kaplan, Rocketdyne, Canoga Park, Calif.

Various aspects of engine design and development where alternatives exist are presented and the type of failure danger associated with each is compared: Clustered engines vs. single large engines; Simplified controls vs overriding and redundant controls; Mode of failure testing. The paper inspects liquid rocket engines as they appear in the current state-of-the-art, regarding safety and reliability for manned payloads.

Propellants & Combustion

The Stability of Laminar Flames, Russell E. Peterson, Howard W. Emmons, Harvard University, Cambridge, Mass.

The Markstein theory of stability of laminar flames is shown to be supported by experimental results on oscillated laminar propane-air flames. Disturbances in appropriate wave length ranges grow and distort while for other ranges disturbances are damped. These facts imply important restrictions on the nature of a turbulent flame and its interaction with the surrounding flow field.

An Experimental Method of Measuring Intensity of Turbulence in a Rocket Chamber, Martin Hersch, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio.

Experimental values of intensity of turbulence in a two-dimensional hydrogen-LOX rocket engine were determined from the spread of a gas jet diffusing in the combustion chamber. The diffusion was determined photographically, using sodium d-line radiation as a flow tracer. A simplified model of turbulent diffusion was used to estimate the intensity of turbulence from the gas jet spreading. The results indicated that the intensity of turbulence is relatively high near the injector but diminishes downstream. The variation of lateral fluctuating velocity with downstream distance was in agreement with theoretical predictions for decaying turbulence in a cold flow accelerating stream. Changes of several operating parameters had little, if any, effect upon the intensity of turbulence.

Metal Combustion Processes, Irvin Glassman, Princeton University, Princeton, N.J.

The author presents some preliminary conclusions on burning characteristics. These conclusions are based on fundamental physical considerations and not on experimental results. An analytical approach to calculate the burning rate of metals is also suggested. This approach differs from the diffusion-droplet approach in that it includes radiation feedback and loss terms. Such terms can be important at the high temperatures of the diffusion film surrounding a metal.

The verification of many of the postulates given can be carried out ideally at some later date on the high-pressure, double-rocket motor flow reactor developed under the subject contract.

The Effect of Flame Configuration on Combustor Performance, C. C. Miesse, Armour Research Foundation, Chicago.

The author concludes that the efficiency of a combustor may be improved by providing increased flame-holding areas and/or additional length of combustor. The differences in the various types of flame-holder configurations become negligible as the combustor length approaches twice the length of the flame envelope. Theoretical results, based on the chemical law of mass action, are verified qualitatively by experimental data.

Problems of Space Travel

Survival Equipment for Emergency Space Vehicle Abandonment, Harold L. Bloom, Missile and Space Vehicle Department, General Electric Co., Philadelphia.

An analogy is drawn between "abandon ship" at sea and in space. The analogy is continued through a discussion of the emergency equipment available to the sailor and parallel equipment which should be available to the spaceman. The discussion points out the increase in "survivability" with increase in components and complexity of emergency equipment. The space "life-raft" and the space "life-boat" are singled out for specific treatment. Preliminary estimates of weights and components are determined. Comparisons are offered for the cases of the items remaining in space and items re-entering and landing on earth. Abandoning an earth satellite is treated as a special case.

The Radiation Problem in Low-Thrust Space Travel, Andrew D. Babinsky, Michael G. Del Duca, Angus F. Bond, Thompson Ramo Wooldridge, Inc., Cleveland.

The discovery of the Van Allen radiation belts, although the nature and energies of the radiation are not precisely known yet, has clearly established the need for: 1) the development of various low-radiation flight schemes which would permit penetration of the zones of high intensity radiation by manned vehicles and 2) the determination of vehicle requirements for proposed flight schemes. Preliminary investigations in addition to presenting magnitudes of radiation expected indicate that the total radiation received can be controlled by proper selection of launch and orbit parameters. Also, it is indicated that a large palyoad advantage can be gained by minimizing radiation due to the reduction in shielding requirements.

How Useful Are Low-thrust Space Vehicles, Ernst Stuhlinger, Army Ballistic Missile Agency, Huntsville, Ala.

The author sketched briefly the evolution of electric propulsion and describes in detail several missions involving the various concepts. The paper concludes with the prediction that electric systems will come into life in their own right and not as all-out competitiors with other systems. Their development should be encouraged as part of the natural evolution of man's technology.

The Advantages of High-thrust Space Vehicles, W. Hunter, J. M. Tschirgi, Douglas Aircraft Co., Santa Monica, Calif.

The authors demonstrate that there is very little difference between microthrust and high-thrust vehicles as far as performance is concerned. But when the relative difficulty of developing reliable hardware is considered, high-thrust vehicles have a definite advantage.

Gas Wave Phenomena

Theory of the Structure of Gaseous Detonations, C. F. Curtiss, J. O. Hirschfelder, University of Wisconsin, Madison.

The authors discuss the structure of gaseous detonation waves. The effects of the transport phenomena, thermal conductivity, viscosity and diffusion are included. The transport phenomena lead to a coupling between the shock and reaction portions of the detonation. Normally this coupling is small and the solutions resemble closely those discussed by Von Neumann. However, if the reaction rate is sufficiently fast at the detonation temperature, the coupling is strong and the solutions are of the Cook type. Experimentally, strong coupling may be achieved by preheating.

Theoretical Analysis and Experimental Measurements of Detonation Induction Distances at Atmospheric and Elevated Initial Pressures, Loren E. Bollinger, Michael C. Fong, Rudolph Edse, Ohio State University, Columbus, Ohio.

The transition phenomenon from deflagration to detonation has been investigated. An empirical relationship involving the combustion temperature, the burning velocity, the sonic velocity in the unburned gas, and the Reynolds number based on the burning velocity has been established to predict detonation induction distances of certain combustible gas mixtures. For mixtures containing hydrocarbons the correlation is not satisfactory. An explanation for this is offered.

Methods of Predicting Composition Limits for Detonation of Hydrogen-Oxygen-Diluent Mixtures, Richard W. Patch, United Aircraft Corporation, East Hartford, Conn.

Two different methods of predicting Chapman-Jouguet detonation limits in hydrogen-oxygen-diluent mixtures are presented for a model of the detonation wave comprising a shock wave followed by an ignition-delay region and a combustion region. In the first method a constant ignition-temperature criterion for the gas behind the shock wave is employed to correlate the experimental data, while in the second method explosion limits determined from chain branching considerations are employed. Various degrees of rotational and vibrational relaxation behind the shock in the ignition-delay region are assumed for both methods to obtain three sets of temperature and pressure conditions behind the shock wave. Both methods are employed to predict detonation limits for various mixtures for which experimentally determined values are in the literature.

It is shown that the constant-temperature criterion computed for a gas having complete rotational relaxation but no vibrational relaxation provides the best correlation with experimental values obtained from the literature.

Dr. Mostafa B. Talaat, an Egyptian-born engineer whose work has been honored on several occasions by the American Institute of Electrical Engineers, has joined the Nuclear Division of The Martin Co. to direct all research and development efforts in the field of energy conversion.

TALAAT

Dr. Talaat holds two patents on thermoelectric generators and one on the cooling of electric machinery, and has published a dozen papers and technical discussions in the authoritative Transactions of the American Institute of Electrical Engineers.

Harry L. Henley has joined Meletron Corp., as Evaluation Engineer in charge of the engineering laboratory. He was previously instrumentation engineer, Research, at Rocketdyne's Propulsion Laboratory.

George J. Vila has been named Washington manager-NASA for Convair Division of General Dynamics Corp., and will be responsible for coordinating all of the division's efforts relating to NASA projects. He will report to **R. B. Swanson,** assistant to the vice president and Washington office manager.

Thomas G. Pownall, formerly in the Convair office at Dayton, Ohio, will succeed Vila as Astronautics' Washington representative.

Willard A. Hughes has been elected general manager of the Microwave Division, Kearfott Co., Inc., a subsidiary of General Precision Equipment Corp.

HUGHES

Hughes has served this division for a number of years as chief engineer and most recently as assistant general manager. In his new capacity, he has appointed **Mr. D. F. Metcalf** chief engineer; **N. P. Weinhouse** as manager of the Engineering Technical office, and **W. R. Biderman** as Quality Control Manager for the Microwave Division.

William H. Newell has been elected Assistant to the President of Ford Instrument Co., division of Sperry Rand Corp. Newell, who retired after 30 years with the company, has been recalled to assist the president in the future technical planning for the company and coordinate its research and development activities. He holds 56 patents and is a recognized authority on inertial systems and computing and control devices.

John C. Christian, former staff consultant, Market Development, for Hughes Aircraft Co., has joined Aeronutronic, a division of Ford Motor Co., as manager of Marketing for Space Technology Operations. He will be responsible for formulating a marketing program for the division's space age products and determining customer requirements in the field of space technology.

CHRISTIAN

Prior to joining Hughes, Christian was manager, Plans and Programs, Crosley Defense Product Div., Avco Corp., and before that was chief of the armament staff unit at Boeing Airplane Co.

Dr. Peter B. Myers has accepted a position as Staff Scientist with the Semiconductor Division of Motorola, Inc. He will be engaged in advanced research and development of semiconductor integrated circuits, and will serve as a division-wide consultant on mechanical problems.

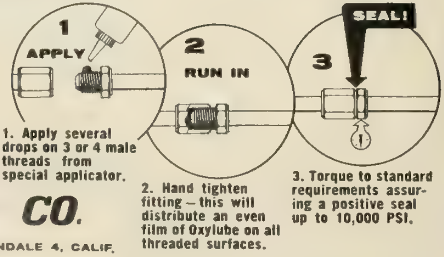
MYERS

Dr. Myers was formerly associated with Bell Telephone Laboratories doing research work on instrumentation for high-frequency characterization of transistors.

Southwest Research Institute has announced three major staff changes: **Maj. Gen. Harry Reichelderfer,** USA, (Ret.), who joined the institute in 1956, has been named administrative vice president. **Dr. James Sharp** and **Henry Korp** have been appointed technical vice presidents.

James G. Dogherty, formerly assistant head, has been promoted to head of the Research and Study department at Vitro Laboratories, and **Morris Lebovits** has been appointed chief of astro-aero sciences at Solar Aircraft Co.

Winfield Shiras, formerly with Westinghouse Electric Corp., has been named vice president and general manager of Telex, Inc., and **Franklin C. Spinney,** formerly a field engineer in the Washington office, has been elected manager of research sales for the Allison Division of General Motors Corp.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contracts

NAVY

$1,865,239—Control Instrument Co., Inc., Brooklyn, N.Y., for design, construction and supply of four missile F. C. switchboards.
$110,000—Boeing Airplane Co., Wichita, Kan., for research on low frequency vibration effects on human performance.
$59,686—North American Aviation, Inc., Canoga Park, Calif., for research in hybrid combustion.
$52,624—Texas Instruments, Inc., Dallas, for research on graded gap semiconductors.
$44,000—King Cowles & Associates, Inc., dba **Robert W. King Construction Co.**, N. Hollywood, Calif., for construction of A.E.C. missile assembly building, Naval Missile Facility, Point Arguello, Lompoc, Calif.
$41,422—University of Chicago, for research on magneto convective instabilities.
$41,040—Carnegie Institute of Technology, Pittsburgh, for research on free energies of surfaces.
$40,775—Rensselaer Polytechnic Institute, Troy, N.Y., for design and construction of a series of bladeless propulsion systems of the duct type.

MISCELLANEOUS

$600,000—Reeves Instrument Corp., subsidiary of **Dynamics Corporation of America**, for the design, engineering and building of new type electric fuzes for an advanced weapon.
$106,000—Yardney Electric Corp., N.Y.C., for the manufacture of extremely powerful silver-zinc batteries for missile application. Subcontract from **Boeing Airplane Co.**

AIR FORCE

Boeing Airplane Co. has sublet three research and development contracts totalling $2,300,000 for work on the *Minuteman* ICBM. These contracts went to **General Motors Corp.**, **Cessna Aircraft Co.**, and **Bendix-Pacific** division of **Bendix Aviation Corp.** Amount of individual contracts not disclosed.
Sylvania Electric Products, Inc., has been awarded a contract calling for delivery of an experimental ultra-high-frequency receiver that will provide 10,000 hours continuous operation. Amount not disclosed.
The Electronics Division of Chance Vought Aircraft, Inc., has received a sub-contract from the **Autonetics Division of North American Aviation, Inc.**, to design and develop the actuator system for the *Minuteman* ICBM. Amount not disclosed.
$10,000,000—Ryan Aeronautical Co., for further production of *Q-2C Firebee* jet-propelled target missiles.
$265,950—Gilfillan Brothers, Inc., Los Angeles, Calif., for oscilloscope, sychronizer set.
$150,000—Stanford University, for continuation of research on "Studies of elastic and inelastic scattering of HE electrons; production and interactions of various mesons; field theory; problems in quantum electro-dynamics."
$62,067—University of California, for research on "X-ray studies of unusual organic molecules."
$27,182—University of California, for continuation of research on "Studies of sampled data control systems."

ARMY

Elkton Division of Thiokol Chemical Corp., received a contract from **Republic Aviation** for design, development and production of solid booster motors for *Swallow* surveillance drone. Amount not disclosed.
$5,974,644—The Martin Co., Orlando, Fla., for engineering services, preparation of repair parts lists, documentation and test hardware and *Lacrosse* missiles and related equipment. (Four contracts).
$2,300,054—Radioplane Div., Northrop Corp., Van Nuys, Calif., for surveillance drones.
$997,859—Paul Smith Construction Co., Orlando, Fla., for reconstruction of Pad 12, Cape Canaveral Missile Test Annex, Patrick AFB.
$600,000—International Telephone & Telegraph Corp.'s Federal Division, Clifton, N.J., for additional ground support equipment for the *Lacrosse* missile. Subcontract from **The Martin Co.**
$556,154—Western Co., Inc., N.Y., for *Nike* spare parts and components. (Four contracts).
$306,000—Hayes Aircraft Corp., Birmingham, Ala., for engineering and design services, ground support equipment for *Saturn*.
$261,700—North American Aviation, Canoga Park, Calif., for rocket engines.
$178,486—E. I. Noxon Construction Co., Los Angeles, for additional nose cone facility items at Vandenberg AFB.
$105,148—Western Electric Co., N.Y., for *Nike* spare parts and components. (Two contracts).
$76,408—Radioplane Co., Van Nuys, Calif., for supplies and services re missile targets. (Two contracts).
$76,630—Hayes Aircraft Corp., Birmingham, Ala., for design, engineering, fabrication and maintenance services.
$70,646—Westinghouse Electric Corp., Micarta Div., Hampton, S.C., for research and development of test cones for nose sections.
$56,364—Douglas Aircraft Co., Inc., Santa Monica, Calif., for repair parts for *Nike* systems.
$49,424—Hayes Aircraft Corp., Birmingham, Ala., for engineering and design services and specialized services for manufacture of special tooling and fixtures of missile components.
$39,876—Auburn Research Foundation of Alabama Polytechnic Institute, Auburn, Ala., for applied research entitled "Heat transfer studies and tests."
$25,000—Metal Hydrides Inc., Beverly, Mass., for 19,348 units of calcium hydride generating charges.

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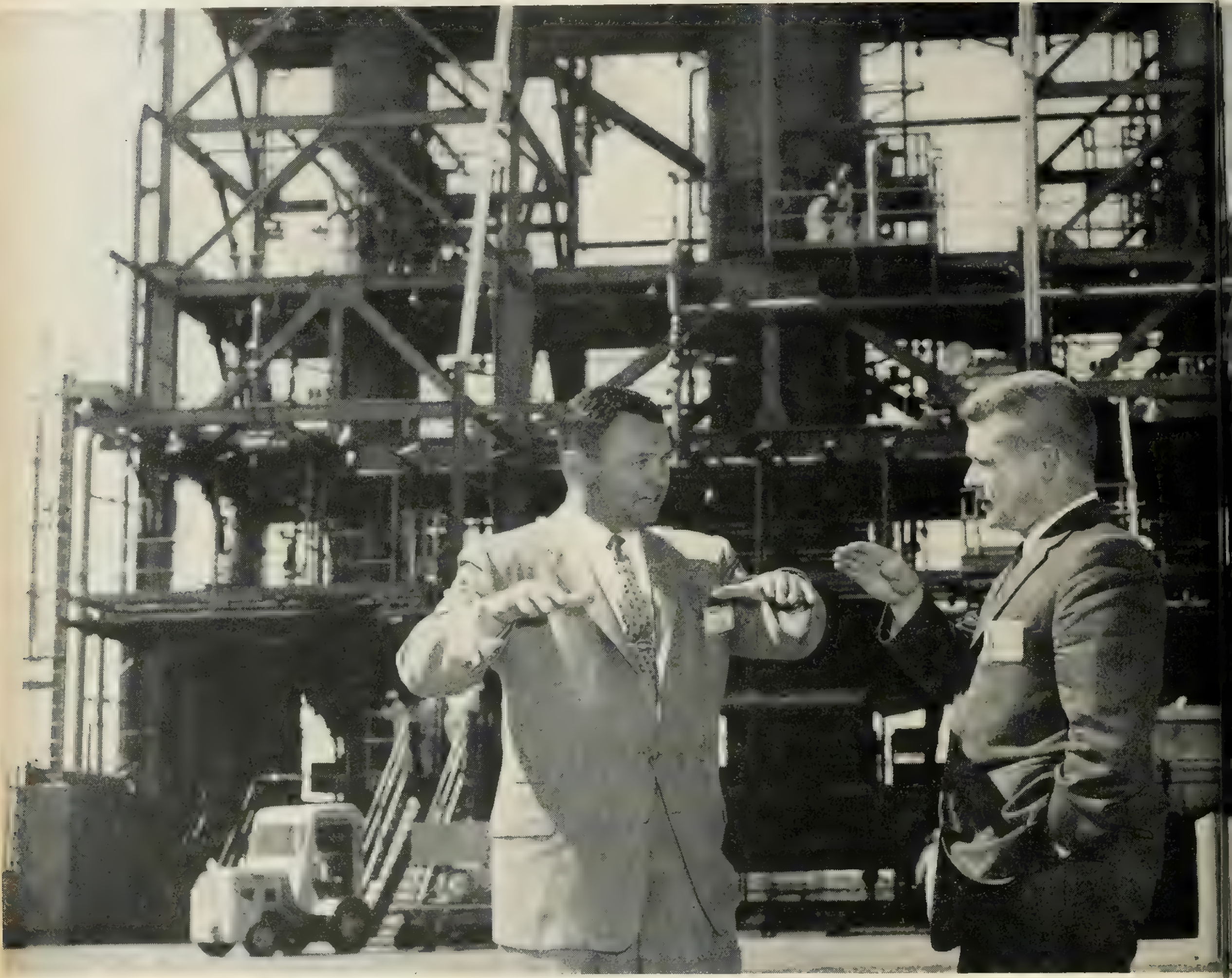
LEADER IN ROCKET PROPULSION — Dan M. Tenenbaum (left), Manager, Test Division, Sacramento Plants, discusses static ground testing with Richard van Osten of the Editorial Staff of MISSILES AND ROCKETS Magazine. Aerojet-General has over 180 test stands for liquid and solid propellant rockets with facilities to conduct tests involving up to a million and a half pounds-thrust. The stand shown above is used to test the mighty Titan engines.



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Aerojet-General Corporation, a Subsidiary of the General Tire and Rubber Company, is one of the outstanding leaders in the research, design, development, and production of both solid and liquid propellant rocket engines. An 18,000 acre site outside of Sacramento, California, is devoted entirely to major missile rocket engine development and production facilities. Aerojet-General has developed and produced propulsion systems that reac like a veritable Who's Who among Missiles. Fo example: Titan, Polaris, Minuteman, Able, Bomarc Vanguard, Regulus II, Aerobee-Hi, Tartar, Hawk Sparrow III, and Genie.

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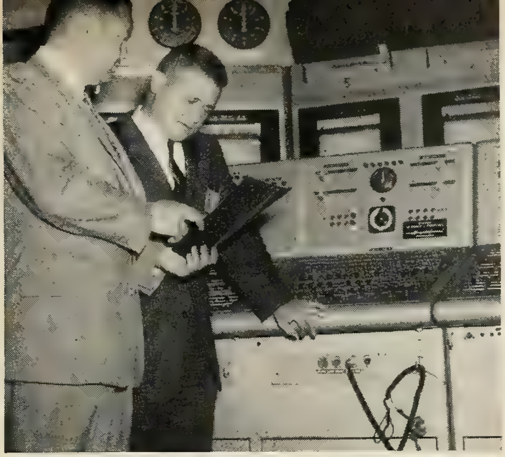
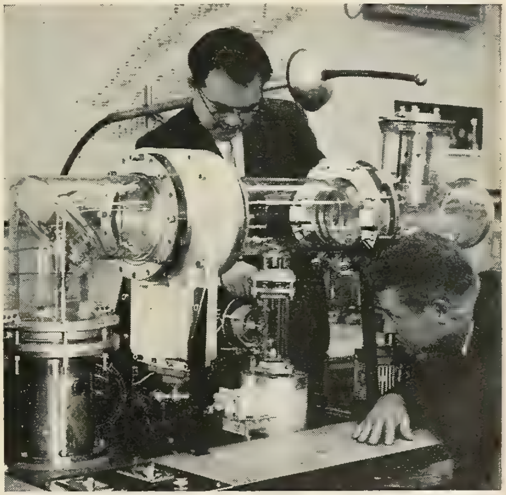


"The production of solid or liquid propellant rocket engines is just one part in today's complex race for space. This missile age of ours requires vast scientific and engineering technology. In addition to this, we must keep abreast of the latest developments within our industry. MISSILES AND ROCKETS Magazine keeps us posted in this market that expands daily." — Dan M. Tenenbaum (left), Manager, Test Division, Sacramento Plants.

"Month-old news to the missile engineer is like the consumer reading last week's weather report. Technical news developments concerning the industry are a day-to-day occurrence. The weekly issues of MISSILES AND ROCKETS Magazine keep us right up to date. Without question, MISSILES AND ROCKETS is a *must* for our money."—Dr. Raymond H. McFee (right), Director of Research, Aerojet-General's Avionics Division.

"Aviation is one thing — the missile/space industry is quite another. Our business is getting missiles into space. Today's missile industry evolved from the old concept of the aircraft-missile business but each is now a separate and distinct industry. We read MISSILES AND ROCKETS for that very reason. It deals 100% with Astronautics."—Marvin L. Stary, Director, Aerojet-General's Systems Division.



"This is a young industry and there are a lot of young people growing up with it. It is absolutely necessary that these young engineers be filled in on every bit of new data as it develops. MISSILES AND ROCKETS provides a complete, clear picture weekly of what's happening in the field of World Astronautics." — Dr. George Moe, (left) Aerojet-General's Space Technology Division.

pplications. In addition, the division is currently esigning optical simulators and training devices. erojet-General diversification is found in the Anti-ubmarine Warfare Division which is developing new type torpedo for the Navy and in the Ord-ance Division which is producing warheads for e Army. Aerojet-General Nucleonics, located at an Ramon, California, is now designing reactor sys-ms to provide power for space vehicles. Another nportant facet of the Nucleonics plant is the study nuclear-propulsion systems for space exploration.

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DECEMBER

AFOSR/Physics Division, Physical Sciences Directorate and NAS/NRC, Conference on Problems Related to Interplanetary Matter, Northwestern University, Evanston, Ill. (Dates still not firm.)

Rocket and Missile Symposium, USAF Arnold Engineering Development Center and ARO, Inc., Arnold Air Force Station, Tullahoma, Tenn., Dec. 1-2.

Eastern Joint Computer Conference, Statler Hilton Hotel, Boston, Dec. 1-3.

National Conference on Application of Electrical Insulation, Sheraton-Park and Shoreham Hotels, Washington, D.C., Dec. 6-8.

American Institute of Chemical Engineers, 52nd Annual Meeting, Sheraton-Palace Hotel, San Francisco, Dec. 6-9.

American Management Association, Briefing Session on the Defense Market, Ambassador Hotel, Los Angeles, Dec. 7-9.

First Aerospace Finishing Symposium, sponsored by Southwest Society of Aircraft Materials and Process Engineers, and Dallas-Ft. Worth Branch of American Electroplater's Society, Hotel Texas, Fort Worth, Dec. 8-9.

Institute of Environmental Sciences, New York Metropolitan Chapter, Technical Symposium and Product Exhibition, Henry Hudson Hotel, New York City, Dec. 10-11.

1960

Sixth National Symposium on Reliability and Quality Control in Electronics, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

American Astronautical Society, Sixth Annual Meeting, New York City, Jan. 14-20.

Institute of Radio Engineers, 1960 Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles, Feb. 3-5.

Engineering Materials and Design Exhibition and Conference, Earls Court, London, Feb. 22-26.

Univac Users Association, Semi-annual Meeting, Greenbrier Hotel, White Sulphur Springs, W.Va., Feb. 25-26.

American Rocket Society, Structural Design of Space Vehicles Conference, Biltmore Hotel, Santa Barbara, Calif., April 6-8.

American Welding Society, 41st Annual Meeting and Welding Exposition, Los Angeles, April 25-29.

National Association of Relay Manufacturers, Eighth Annual Conference on Electromagnetic Relays, Oklahoma State University, Stillwater, May 3-5.

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Needed: A Central Materials File

Stories in this special materials edition of M/R bring out one fact very clearly:

A great deal of research, both basic and applied, is going on in this country in every phase and facet of the materials field; hundreds of millions are being spent by private industry, universities and independent laboratories, the services and other government agencies every year.

But there is not enough communication of results. The distribution of information on the discoveries made in all of this research lags many months behind the discoveries themselves. This is true, apparently, on an industry-to-industry basis, on a government-to-industry basis and even on a government agency-to-government agency basis.

Part of this is due to the protection of proprietary rights within industry. A company which discovers a new method of improving the tensile strength or the heat resistance of a material is naturally reluctant to disclose this valuable secret until it has reaped the benefits of the achievement.

More often, however, the facts are available; they have been published in unclassified form. An example, as pointed out elsewhere in this issue, is that eight months after unclassified publication of technical papers on notch sensitivity of high-tensile steels, project engineers writing the specifications for solid-fuel rocket motor cases for nationally critical programs had never heard of notch sensitivity.

It seems apparent that in the field of structures and materials—and more so in this field than in any other because it covers almost every conceivable area of engineering—three things are needed:

First is open-mindedness on the part of the engineers and the companies and agencies which employ them—open-mindedness in the sense of being willing to compare their particular requirements with all known available materials and their capabilities.

Second, a willingness of industry and government to encourage the fastest possible dissemination of their findings in the research and experimental fields.

Third, the establishment of a central repository where information on all findings can be obtained quickly.

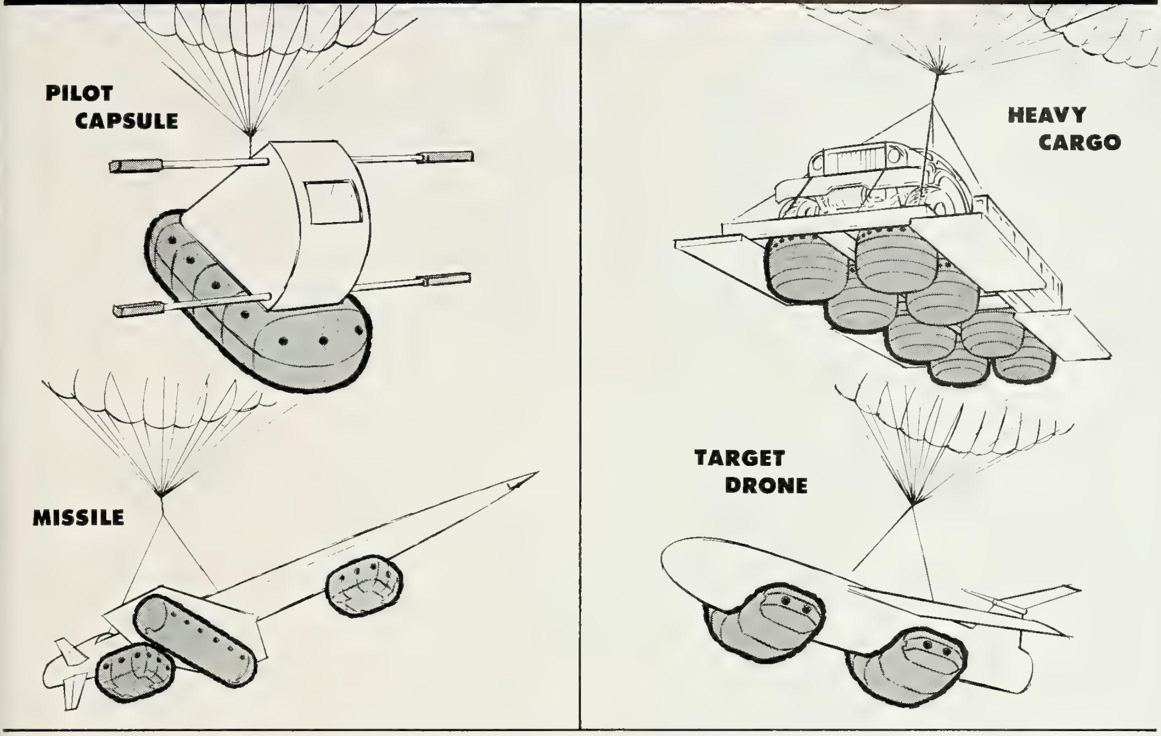
It is quite possible that with the accomplishment of the third requirement, the first two would follow easily and naturally. At the moment we have nothing even approaching such a facility, although some of the professional societies and some government agencies have either made a stab at it or are planning to.

We suggest that this is not a task for any one agency or group (unless it should be established as a separate agency unto itself) but that it should be a joint undertaking of some of the great American professional organizations.

The American Rocket Society, which met in Washington last week, certainly has a vital interest. So do the American Institute of Chemical Engineers, the American Chemical Society, the Society of Automotive Engineers, the American Coke and Coal Chemicals Institute—and dozens of others. They could collect the vast amount of data on materials, the combinations of materials and the treatment of materials. With the aid of the giant computers and data storing equipment available today, millions of facts gleaned from millions of experiments could be available to anyone needing them. It would be a project and an achievement worthy of such a joint effort.

CLARKE NEWLON

PNEUMATIC RECOVERY SYSTEMS / another product of Air Cruisers research



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MOON GARDEN

You can't grow anything on moon soil . . . but Republic is . . . raising turnips, carrots, beets and snap beans i lunar greenhouse experimental garden. ≻≻≻ Republic is working on lunar garden studies as part of a researc program to determine the feasibility of establishing a base on the moon. ≻≻≻ Hyman Stein, manager of space projects and studies for Republic's Applied Research and Development Division . . . and his "green thumb staff" (Bill Taufman seen here), maintain a constant, studious vigil over these tests. ≻≻≻ A basic aim is to determine at how low a pressure vegetables can be grown to maturity. The lower the pressure, the less weight of the greenhouse structure. And weight is critical in delivering a payload to the moon. ≻≻≻ These experiments will determine whether significant increases in crop production can be obtained by lengthening the working day as past tests indicate. Our Moon Garden studies are but one of many bold concepts under development as part of Republic's multi-million dollar exploration into the realm of advanced aircraft, missiles, space travel and space.

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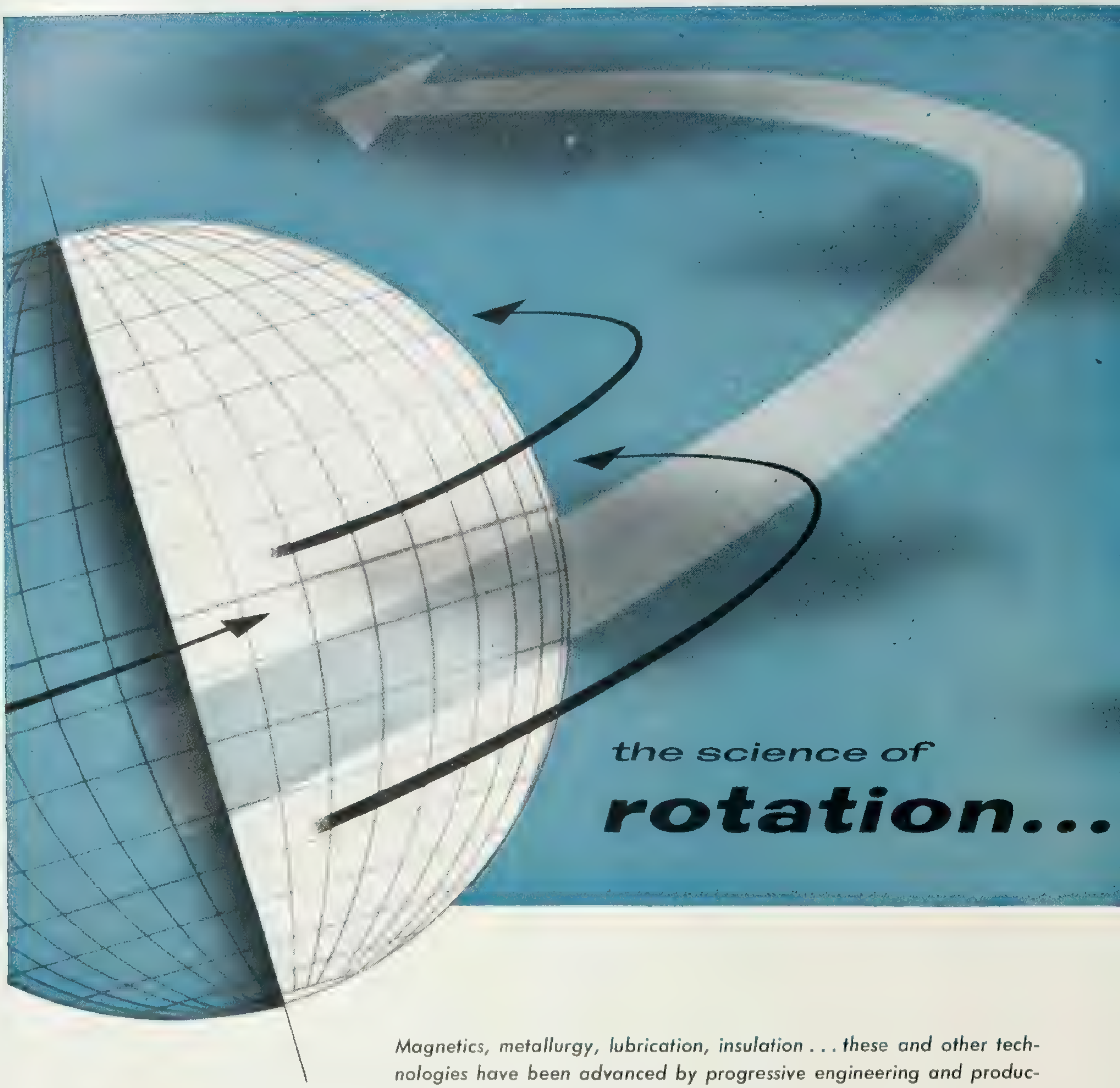

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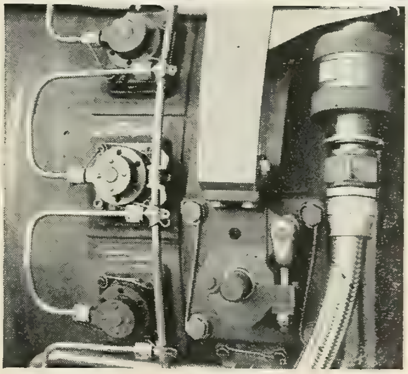

Aeroquip Hose of Teflon with patented* ***"super gem"*** Reusable Fittings and 3200 Quick Disconnect Coupling shown here on the Hound Dog Missile, are also used on the external check-out system.

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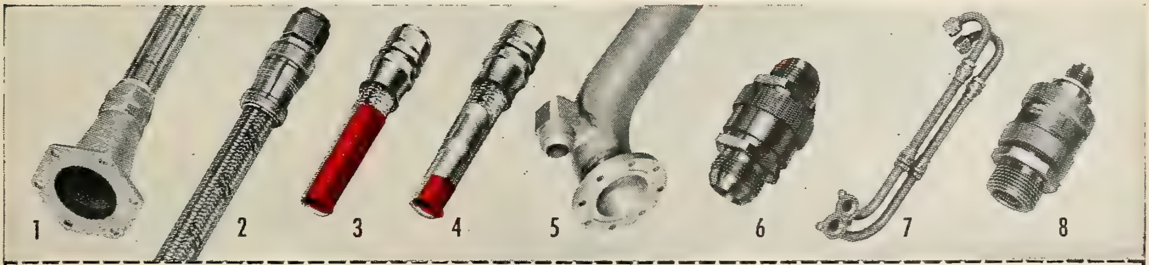

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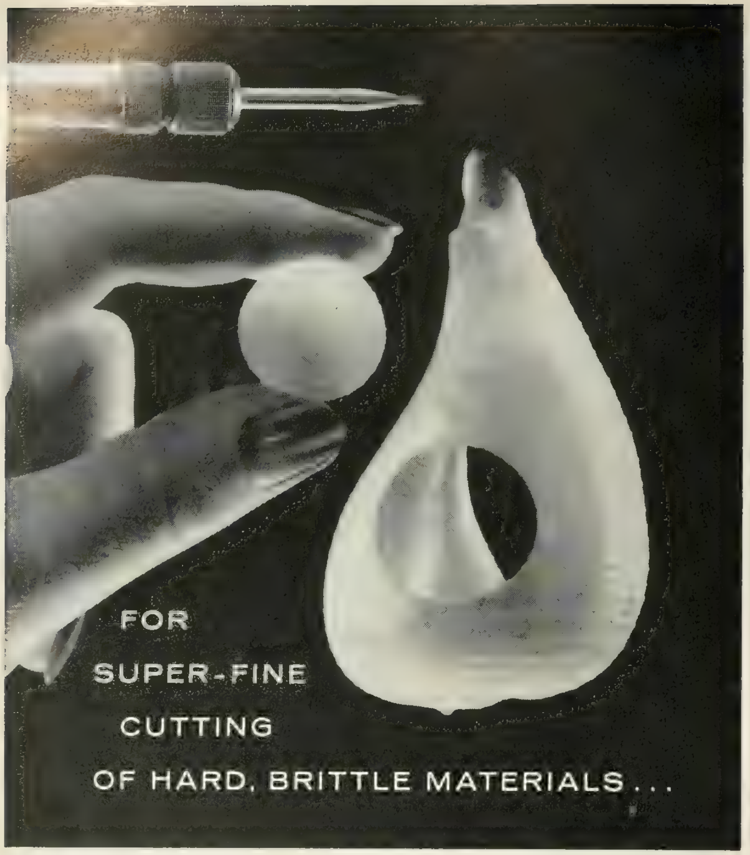

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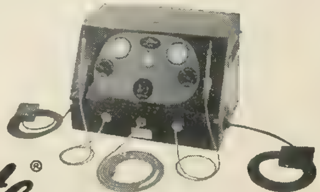

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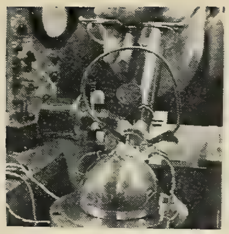
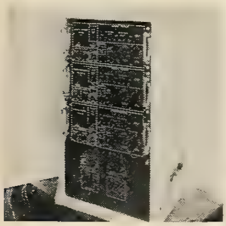


COVER: This shiny ball of beryllium is the heart of a new kind of gyroscope being developed by Minneapolis-Honeywell. It is designed to spin at high speed while held in position by electrical forces.

COLD-CATHODE electron tube under development by Westinghouse research laboratories uses silicon carbide (inside the cartridge) as emitter. A survey of semiconductor industry starts on p. 23.

MINIATURE tape recorder by Ampex recently survived in good working order after trip in instrumentation portion (similar to above) of missile nose cone. For the story, turn to p. 31.



RADAR simulator by Servonics is being used by Navy for simulating blips of attacking enemy. It may be used to train anti-missile batteries. See the report beginning on p. 37.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

32,200 copies of this issue printed

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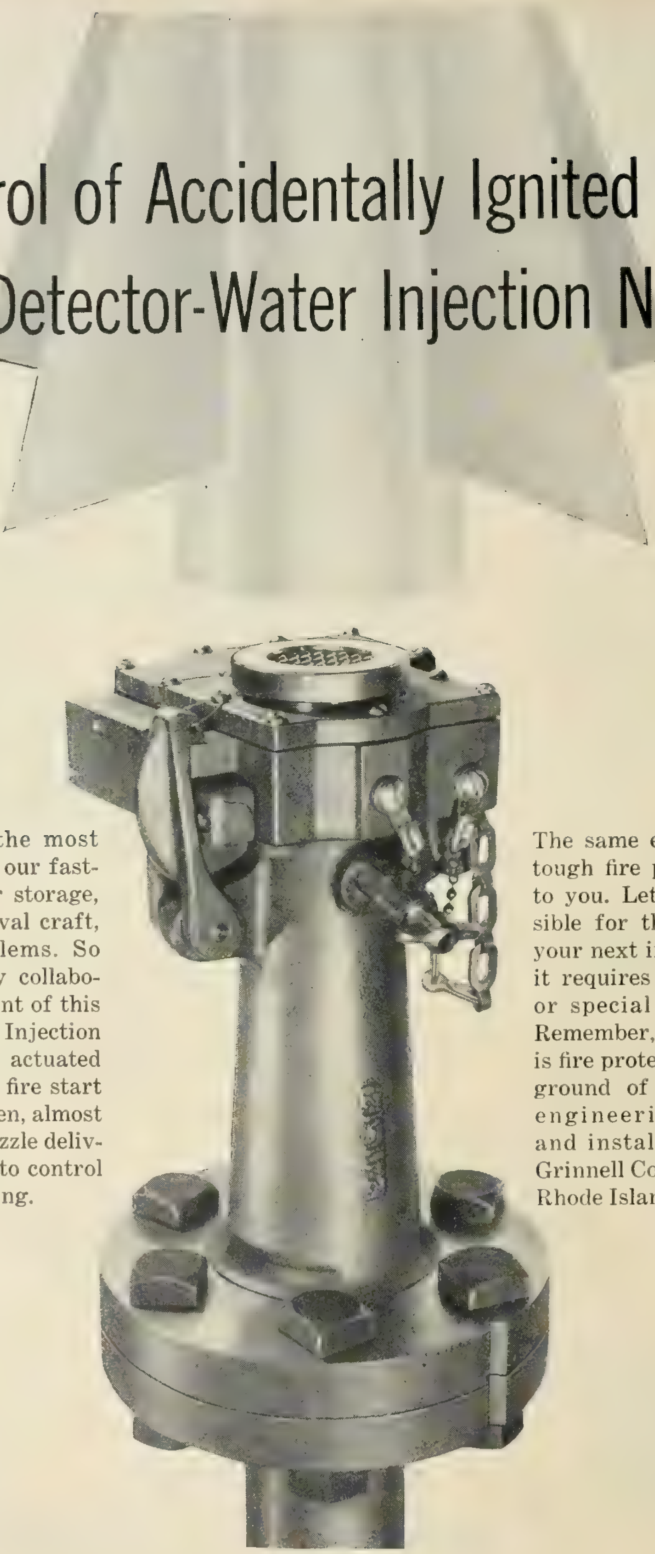
For Control of Accidentally Ignited Missiles ...Fire Detector-Water Injection Nozzle



Missiles are among the most destructive weapons in our fast-growing arsenal. Their storage, particularly aboard naval craft, creates critical problems. So Grinnell and the Navy collaborated on the development of this Fire Detector - Water Injection Nozzle. This device is actuated by shock waves should fire start in a missile booster. Then, almost instantaneously, the nozzle delivers a stream of water to control or extinguish the burning.

The same experience in solving tough fire problems is available to you. Let Grinnell be responsible for the fire protection on your next installation—whether it requires standard equipment, or special development work. Remember, Grinnell's specialty is fire protection . . . with a background of successful research, engineering, manufacturing and installation for 89 years. Grinnell Company, Providence 1, Rhode Island.

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SILICONE NEWS from Dow Corning

Seals With ± Zero Tolerance

SILASTIC® RTV
SILICONE RUBBER

Forms Airtight Weather-Proof Enclosure

Aircraft and missile engineers have found an effective material for sealing airframe members and other parts. It's Silastic RTV, the Dow Corning room temperature vulcanizing silicone rubber.

In the F-102 and F-106* canopies, for example, engineers at Convair Division of General Dynamics (San Diego), specified that the windows be "floated" in Silastic RTV. This window seal maintains cockpit pressure but resists cracking and checking and other effects of weathering and ozone. It remains pliant in spite of stratospheric cold.

And Silastic RTV seals are easy to form. Semi-fluid in nature, the RTV can be applied by caulking gun directly to the spot you want sealed. In a short time (you can vary the time from a few minutes to a whole day) the fluid sets up to a rubbery solid, and you have a seal with tolerances to ± zero. Other uses of Silastic RTV, aside from caulking and sealing, include potting of electronic gear and making of molds for prototype parts. Various consistencies are available for application methods other than caulking gun. For further information on this product, send for literature: "How To Use Silastic RTV." Address Dept. 7623.

TYPICAL PROPERTIES OF SILASTIC RTV SYSTEMS

After Vulcanizing (24 hours at 77 F)	*Fluid Grade*	*Caulking and Putty Grade*
Hardness, Shore A	30 to 65	20 to 55
Tensile Strength, psi	250 to 850	225 to 450
Elongation, percent	100 to 250	120 to 400
Brittle Point, degrees F	−100	−178 to −100
Shrink, linear, percent		
after 3 days* at 77 F	0.6	—
after 6 days* at 77 F	0.8	1.2 to 1.6
after 14 days* at 77 F	1.1	—
Water Absorption, percent after 70 hours immersion at 212 F	1.0	1.0
Working Time	10 min. to 3 hr	2 to 5 hr

*SHOWN: F-106 DELTA DART.

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Kinetics design shrinks missile switch from 50 lb to 7 lb

As shown in this bottom view, the actual switch is much smaller than the bracket. Kinetics can put a 200-pole, double-throw switch in less than 200 cubic inches.

The original main power changeover switch in the Atlas missile that switched from ground supply to internal electrical supply just prior to launch weighed 50 lb. Now, thanks to the design ingenuity of Convair-Astronautics engineers who cut the number of circuits from 32 to 20 and to Kinetics Corporation engineers who provided a new design concept, the switch and bracket assembly weighs only 7 lb. Since a pound of savings in the missile-borne weight adds about a mile to the missile's range, this saving is truly spectacular!

The new Kinetics motor-driven switch is more rugged and reliable than previous designs and is impervious to shock and vibration. A typical Kinetics switch exhibits no contact chatter over the whole vibration spectrum, from 5 to 2000 cycles, 40 G's. The voltage drop across typical switch contacts is less than 10 millivolts at 22 amp.

The high-density design results in many circuits per cubic inch, saving space. There are no permanent magnets or springs, no latching devices. This is truly a motor-driven switch using no elements of relays. The switch can be transferred at 40 G's, 2000 cycles. Once it's transferred, no power is required to hold it in position, saving batteries. Write or phone for more information on how this switch can be adapted to your requirements. Kinetics Corporation, Dept. K-13, 410 S. Cedros Avenue, Solana Beach, Calif. SKyline 5-1181.

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Washington Countdown

IN THE PENTAGON

Fate of *Nike-Zeus* . . .

in the FY 1961 budget appears dim as far as getting the more than $1 billion needed to begin production is concerned. Army officials are looking more hopefully at the idea of getting production money in a supplemental appropriation bill later next year for the big **Western Electric** AICBM.

• • •

Dyna-Soar money . . .

still left in the Air Force's pocket for FY 1960 is reported to total about $35 million. Some new word on contracts for the **Boeing-Martin** spacecraft is expected by Christmas.

• • •

Super Lockheed *Polarises* . . .

designed to travel 2500 miles are being proposed as a possible Navy answer to the Air Force's *Minuteman.* The *Polarises* would be deployed on fleet ballistic missile submarines larger than current models or on surface ships.

• • •

Air Force astronauts . . .

are being quietly trained for military space missions. The training program is generally similar to the one being undergone by the inter-service group of astronauts taking part in NASA's *Project Mercury.*

ON CAPITOL HILL

Space patent policies . . .

will get a second going over in less than two weeks. A House Space Subcommittee investigation of NASA patent regulations in early December will be followed by a Senate Monoply Subcommittee investigation of federal scientific patent policies in general.

• • •

Unfinished business . . .

that will confront Congress when it returns in January includes:

. . . Proposed bills that would further reorganize the Armed Forces in the direction of greater unification.

. . . An expected blistering report from the House Hébert Subcommittee's investigation of the "munitions lobby." The subcommittee plans to call for stricter legislation.

. . . Proposed bills that would strengthen the weapon system concept of developing defense projects.

. . . A rear-guard fight to strip the Armed Service Committees of power to authorize missile procurement programs beginning in 1961.

At NASA

Space budget problems . . .

for NASA include whether to go for a sizeable supplemental appropriation in January or lump all requests in its new budget for FY 1961. Speculation on how much NASA will seek for '61 is ranging between $750 million and $1 billion.

• • •

A "white paper" . . .

outlining U.S. national objectives in space is understood to be under preparation by NASA officials. It would be used to support NASA's space programs. However, NASA Chief T. Keith Glennan swears "up and down" that he knows nothing about the paper.

• • •

The Thanksgiving moon shot . . .

was dogged by difficulties. The *Able* stage of the *Atlas Able* rocket was damaged and NASA officials had to scrounge around for a substitute. (They took one scheduled for a *Tiros* shot next year.) And the *Atlas* adapter ring was bent twice—once each time an *Able* vehicle was hoisted into place.

• • •

No chances were taken . . .

that the *Atlas Able* finally assembled would blow up during a static test as the last one did in October. The solution was simple: NASA skipped the static test altogether.

AROUND TOWN

A huge red rocket . . .

may be under development despite Soviet denials. The sun shot forecast by Soviet Deputy Premier Mikoyan would have to be travelling at 25.5 miles/second at burnout—a feat requiring a new high energy fuel or a booster with upwards of a million pounds of thrust . . . or both.

• • •

Lunik III is doomed . . .

to a short life because of orbit problems. Soviet Space Scientist Leonid Sedov told U.S. colleagues that torsional forces from the sun are pushing *Lunik III* closer and closer to the earth because of the high angle of inclination —70 degrees—of the space vehicle's orbit from the equator.

• • •

Other reports . . .

heard around the nation's capital:

. . . The Russians may hold a convention of Soviet rocket experts.

. . . *Jupiter* shipments to Italy are expected to begin early next year.

AEROJET
for rocket power:

ARMY'S HAWK

Solid-propellant rocket engines for the Army's ground-to-air HAWK were developed and are being manufactured at Aerojet's Solid Rocket Plant near Sacramento, California.

AEROJET-GENERAL CORP.

THE GENERAL TIRE

A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

Engineers, scientists—investigate outstanding opportunities at Aerojet. (Plants at Azusa and near Sacramento, Calif.)

the missile week

Industry Countdown

MANUFACTURING

Underground silo launching . . . for *Minuteman* is proving much tougher than anticipated. Initial tests have shown some radical new approaches are needed in the design of the silo to overcome destructive acoustics and heat generated at blast-off. The problem is so serious, the Air Force reportedly is considering switching *Minuteman* to an elevator type launcher similar to the one to be used by *Titan*, which raises the missile out of the silo for launching.

• • •

France holds poor market . . . prospect for U.S. missile suppliers. The 1960 French defense budget earmarks only $22 million for development of a long range ballistic missile. About $66 million is allocated for three French Army *Hawk* anti-aircraft missile units. These are being produced jointly with Germany, Belgium, Holland and Italy under the system managership of a French firm—**Thomson-Houston Co.**

• • •

Dispersion of *Snark* . . . missiles now "bunched up" at Presque Isle AFB in Maine is being proposed to improve their value as a deterrent weapon. Idea would be to scatter a squadron—putting two missiles to a "satellite site" consisting of a $250,000 tilt-up reinforced concrete building capable of withstanding 20 psi overpressures. A number of dispersed *Snarks* would be a cheap method, it is argued, of forcing up the cost to an enemy of knocking them all out.

• • •

Anticipating a boil-up . . . in Congress, DOD is now moving to insure greater small business participation. It has invoked a mandatory program applicable to all procurement contracts over $1 million. The program replaces a voluntary one which resulted in only a slight increase in small business subcontracting in the first six months of this year.

• • •

New steel alloy . . . packing about 7% more strength per weight unit than other structural alloy steels is claimed by **U.S. Steel.** Called "Strux," the alloy can be heat treated to develop tensile strengths of 280,000 to 300,000 psi for use in missile parts.

PROPULSION

Cermetic nozzle . . . 2-in. in diameter developed by **Nuclear Materials and Equipment Corp.** has withstood a 60-sec. blast of gases at over 4500°F. The alloy's composition has not been revealed, but it is said to be lighter than most used in R&D nozzles for the same temperature range.

• • •

Good stability and 255 I_{sp} . . . are claimed for **Grand Central Rocket's** new "Nitrosol" solid fuel—a polymer based on nitrocellulose. Process and quality control are suited for mixing, casting and curing at launch site.

• • •

Rocket engines for autos . . . are being developed at **Hagerty Research & Development Co.,** Tucson, Ariz. Fuel is nitrate and cellulose solid. Company claims when perfected, the engine can power a car for 10 hours on 50 cents worth of fuel. Speed: undisclosed.

ASTRIONICS

Little hope . . . is held for thermomagnetic generation of power. Navy research shows the efficiency of such devices is too low.

• • •

Russians are recanting . . . their reported claim of a breakthrough in thermoelectricity (M/R, Nov. 16, p. 11.) They admit the device which supposedly obtained a thermal efficiency of 182% doesn't exist and was, in fact, nothing more than an ordinary heat pump.

• • •

Look for NASA contract . . . decision soon on Sunflower 1 (solar heat source) and Snap 8 (nuclear heat source). Contenders are **Thompson Products, Sunstrand, Allison** and **AiResearch Mfg.** Big requirement is 10,000-hour operational life.

WE HEAR THAT—

Unsuccessful bidders . . . for NASA contracts soon may be told why they lost out—a new policy . . . The part **Bell Aircraft** may play in the Air Force *Dyna-Soar* program is still undecided . . . AiResearch Mfg. has come up with a 50-pound closed-circuit oxygen system for moon explorers . . . a copper-doped germanium crystal infrared detector has been developed by **Hughes Aircraft's** Santa Barbara Research Center which reported can track space satellites and ICBM's at extreme distances. Device is said to be six times as sensitive as similar-type detectors in 8-to-25 micron range . . . and **Summers Gyroscope** is discussing possible mergers with several companies.

More About the Missile Week on Page 41

FABRICATION TESTS SHOW...

New Titanium alloy takes th

...in strength...in weight...in reliability...in pri

Titanium rocket-motor cases can be built at least 30 percent stronger (or lighter) than best available alternate metals; provide permanent corrosion resistance without protective coatings; withstand temperatures from –400°F to +800°F; will not absorb moisture which distorts critical parts in storage.

Completed assemblies give a spectacular two-way pay-off . . . immediately; provide a growth potential virtually unlimited.

The alloy: Ti-13V-11Cr-3Al, the beta titanium alloy. Now available from Titanium Metals Corporation of America at commercial lead-times (billet, 2-3 weeks), beta may well become the metals story of the year.

Welding of titanium at P&WA is based on the company's experience in production of more than 5800 jet engines containing titanium parts. Weld strength of beta titanium alloy is considerably improved by cold working the weld.

End Closure Titanium Forgings produced by Wyman-Gordon Company and machined by P & WA, will be *girth welded* to the flow-turned cylinders. Bosses are an integral part of the closures.

Flow-turning from roll-forged rings, makes feasible production of full-scale titanium rocket cases, since it yields integral cylinders, eliminates need for longitudinal welds, conserves input metal.

Pilot rocket-motor cases manufactured by P & Whitney Aircraft from beta titanium a Ti-13V-11Cr-3Al have been consistently bu tested at levels in excess of 235,000 psi – a b strength/density ratio of 1,340,000.

So successful has been its titanium prog that Pratt & Whitney Aircraft considers production of full-scale titanium cases can easily realized. Estimated initial burst streng a conservative 180,000 psi – a burst streng density ratio of 1,000,000. Readily attainab 1,250,000.

Reasons for optimism, spelled out by P&W engineers are:

1. **"The welded beta titanium alloy is capable considerable plastic deformation prior to r ture. As welding has improved, the fail origins have moved into the thin wall (of case itself). With beta titanium, the case te but doesn't fragment.**

2. "We have successfully tested small scale titani cases with a steel equivalent yield strength w beyond the 300,000 psi point. Considering t the metallurgy of metastable beta titanium all is not far beyond its infancy, conservatively c would predict strengths substantially higher th the 320,000 psi equivalent as being qu possible.

3. **"Beta titanium has to develop (only) 140,000 to be equivalent to 220,000 psi steel (which almost near steel's top limits). But titaniu great potential above other alloys is reflected the high figure for practical (based on 5 elongation) yield strength. At 180,000 be titanium is equivalent to steel at 280,000 psi; 200,000 psi, beta titanium is equivalent to steel 320,000 psi. 200,000 psi in beta titanium is pos ble, and obviously would mean substantially i creased payload to the moon or out into spa**

4. "Apart from the strengths attainable in the be titanium alloy, there is another property of co siderable significance. Like other titanium alloy it has excellent resistance to corrosion und normal atmospheric conditions, in salt water well as in many other media.

"In considering the long time storage problem with rocket cases – a pit in a thin-walled casin can be catastrophic – we would regard the bet titanium alloy, as the outstanding materi under consideration."

ead in rocket case construction

PRATT & WHITNEY AIRCRAFT SURVEY OF ROCKET CASE MATERIALS

GENERAL PROGRAM

The goal: "A material capable of reaching 300,000 psi yield strength in steel, with a considerable development margin."

The result: "While this goal had to be modified for steel cases, we have successfully tested small scale titanium cases with a steel equivalent yield strength well beyond the 300,000 psi point."

Conclusions: 1. "By exercising reasonable care, the development of full scale (steel) cases at 240,000 psi is perfectly feasible.

2. "Small scale (titanium) cases have been burst at stress levels as high as 260,000 psi . . . we are convinced that reliable cases can be manufactured (from titanium) at yield strength levels of 180,000 psi and over . . . at 180,000 beta titanium is equivalent to steel at 280,000 psi.

"At 200,000 psi beta is equivalent to steel at 320,000 psi. 200,000 psi beta is possible and obviously would mean substantially increased payload to the moon or out into space."

SPECIFIC COMPARISON: Strength

Alloy	Density	Practical Yield Strength (5% elongation)
Ti-6Al-4V	0.161= /in.^{3}	155 ksi = steel at 270 ksi
Ti-13V-11Cr-3Al (Beta)	0.175= /in.^{3}	180 ksi = steel at 280 ksi
		190 ksi = steel at 305 ksi
		200 ksi = steel at 320 ksi

Burst Test Results show titanium has provided consistent burst strengths of 235,000 psi — a burst strength/density ratio of 1,340,000. Failure occurs in the wall of the case itself — not the weld zones. Titanium cases do not fragment.

SPECIFIC COMPARISON: Corrosion Resistance

Steel: "All of the low-alloy constructional steels which have been discussed are subject to general rusting and, far more serious, to pitting type corrosion during machining, welding, heat treatment, pressure testing and final storage. Corrosion pits can act as severe stress-raisers and, in conjunction with hydrogen, have been demonstrated to cause catastrophic failure. It therefore goes without saying that pitting corrosion is a serious hazard."

Titanium: "Like other titanium alloys, the beta titanium alloy has excellent resistance to corrosion under normal atmospheric conditions, in salt water as well as in many other media.

"In considering the long-time storage problems with rocket cases—a pit in a thin-walled casing can be catastrophic — we would regard the beta titanium alloy as the outstanding material under consideration."

• Reliability and growth . . . the parallel

Pratt & Whitney Aircraft data reveal rocket-cases can *now* be built from beta titanium at strengths 17 percent greater than alternate metals, with beta titanium's strengths bounding forward under a minimum of development.

A striking parallel exists in liquid-fueled rocketry where titanium alloy Ti-6Al-4V was selected for helium storage bottles in the Atlas missile because of its strength/density ratio. Airite Products, Inc., a leading supplier of the titanium vessels, reports:

"Minor modifications in processing techniques and continuous tightening of tolerances and other variables have shown an increase from the original 5400 psig average burst pressure to the present average which is in excess of 9000 psig.

"This has been done without increasing the weight of the article by one ounce. Weight of the unit, incidentally is controlled to a tolerance of plus or minus one-half pound, on a weight of 79 pounds, and volume is controlled and guaranteed to plus or minus one percent."

While the performance of the titanium pressure vessels has been almost doubled, the price has been reduced almost 50 percent — and the missile has become operational.

• When a case fails, so does the missile

The price of completed beta titanium rocket-cases is now estimated at 2½ times the price of other metals, with titanium cases virtually in their infancy. Should the titanium cost difference remain, the pay-off would still be two-fold:

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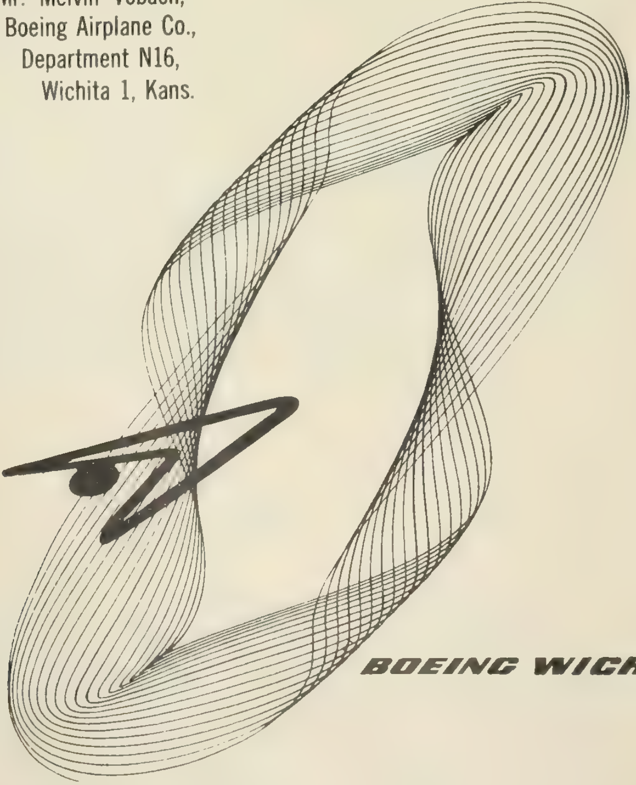

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—when and where—

DECEMBER

Rocket and Missile Symposium, USAF Arnold Engineering Development Center and ARO, Inc., Arnold Air Force Station, Tullahoma, Tenn., Dec. 1-2.

Eastern Joint Computer Conference, Statler Hilton Hotel, Boston, Dec. 1-3.

National Conference on Application of Electrical Insulation, Sheraton-Park and Shoreham Hotels, Washington, D.C., Dec. 6-8.

American Institute of Chemical Engineers, 52nd Annual Meeting, Sheraton-Palace Hotel, San Francisco, Dec. 6-9.

American Management Association, Briefing Session on the Defense Market, Ambassador Hotel, Los Angeles, Dec. 7-9.

First Aerospace Finishing Symposium, sponsored by Southwest Society of Aircraft Materials and Process Engineers, and Dallas-Ft. Worth Branch of American Electroplater's Society, Hotel Texas, Fort Worth, Dec. 8-9.

Institute of Environmental Sciences, New York Metropolitan Chapter, Technical Symposium and Product Exhibition, Henry Hudson Hotel, New York City, Dec. 10-11.

1960

Sixth National Symposium on Reliability and Quality Control in Electronics, Statler-Hilton Hotel, Washington, D.C., Jan 11-13.

American Astronautical Society, Sixth Annual Meeting, New York City, Jan. 18-21.

Institute of Radio Engineers, 1960 Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles, Feb. 3-5.

Engineering Materials and Design Exhibition and Conference, Earls Court, London. Feb. 22-26.

Univac Users Association, Semi-annual Meeting, Greenbrier Hotel, White Sulphur Springs, W.Va., Feb. 25-26.

American Rocket Society, Structural Design of Space Vehicles Conference, Biltmore Hotel, Santa Barbara, Calif., April 6-8.

American Welding Society, 41st Annual Meeting and Welding Exposition, Los Angeles, April 25-29.

National Association of Relay Manufacturers, Eighth Annual Conference on Electromagnetic Relays, Oklahoma State University, Stillwater, May 3-5.

Fourth Annual Summer Conference on Vacuum Metallurgy, New York University's College of Engineering, NYU University Heights Campus, (Bronx), New York City, June 2-3.

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Revolutions for Total Range	2,048
Volts D.C.	10.5
Current (ma.)	20
Inertia (gm. cm.^{2})	20
Unit Diameter (in.)	$1\frac{7}{16}$
Unit Length (in.)	3
Life	10^6 Revolutions or 10^3 hours
Static Torque (in.-oz.)	2 (break) 1 (running)
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Maximum Speed (RPM)	600

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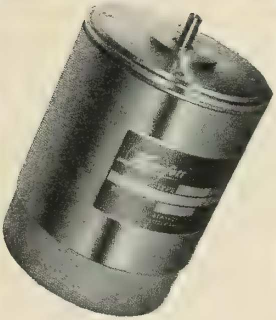

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TYPICAL CHARACTERISTICS **SIZE 25**

Type Resolver	Transmitter	Control Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	$400\underline{/80°}$	$8500\underline{/80°}$
Secondary Imped.	$260\underline{/80°}$	$14000\underline{/80°}$
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

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TYPICAL CHARACTERISTICS

	Size 11 (R860)
Excitation Voltage (400 cps)	115
Volts at 0 rpm (RMS)	.020
Volts at 1000 rpm (RMS)	2.75
Phase shift at 3600 rpm	0°
Linearity at 0-3600 rpm	.07
Operating Temperature Range	−54° +125°

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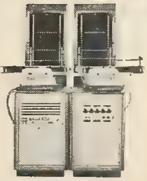
Miniature Floated Gyro

Electrohydraulic Servo Valve

Scanalog 200-Scan Alarm Logging System



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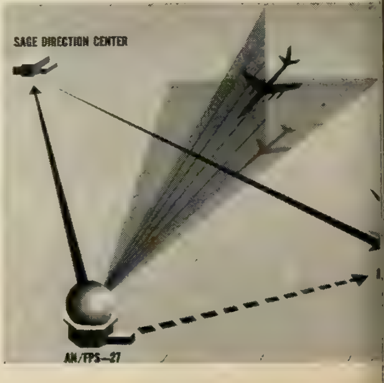
CAPABILITIES FOR DEFENSE

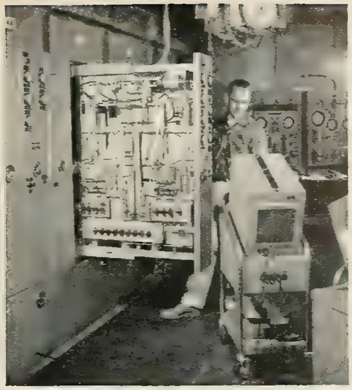
Westinghouse AN/FPS-27 Radar in operation at an Air Defense Command site

A single Westinghouse radar gets a 3-D fix on the enemy...dilutes his jamming ability

The AN/FPS-27, versatile 3-D radar designed by the Westinghouse Electronics Division for the Air Force's Rome Air Development Center, is achieving new standards of performance, reliability . . . and economy. Now under contract from the Rome Air Materiel Area, this high-power, stacked beam radar gathers range, azimuth and height data quickly and accurately while eliminating unwanted signals. These comprehensive functions in a single radar represent the application of the latest state of the art radar techniques to our nation's early warning defense.

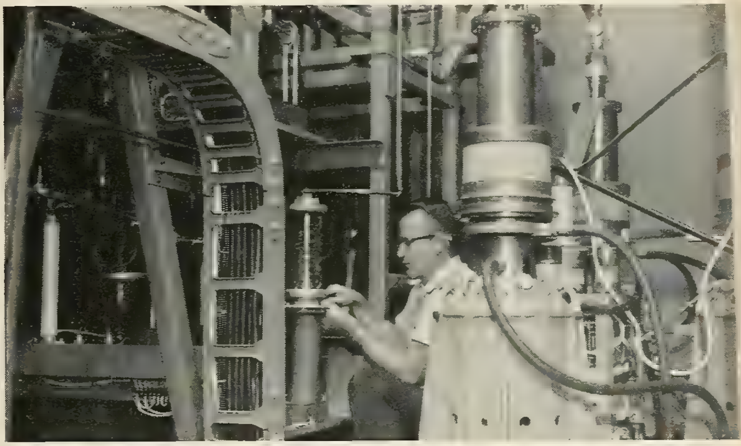


Here is the management team responsible for the development of the AN/FPS-27—within budget and on schedule. This team is typical of the Westinghouse practice of matching alent to the job.

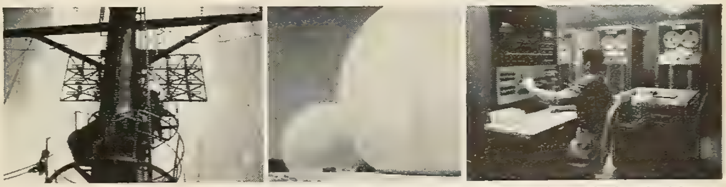


MAINTENANCE EASE: AN/FPS-27 design stresses reliability and maintenance accessibility. A separate monitor console calibrates the receivers remotely. Equipment troubles are automatically indicated. Sub-assemblies can be replaced rapidly in case of circuit malfunction.

UNIQUE CONSTRUCTION DESIGN of the antenna system permits the inclusion of the latest 3-D height-finding techniques. Range, azimuth and height data can be automatically fed to a computer to form a composite picture of the air defense sector.



EASE OF OPERATION: One man operates the entire transmitter room. This is typical of the operational ease of the Westinghouse designed AN/FPS-27. A minimum team of six specially trained men can handle the operation and maintenance of the entire facility.



The AN/FPS-27 is a part of a broad Westinghouse effort in shipboard, tactical and airborne radar. Current simulation studies at the Air Arm Division, utilizing the latest digital computer facilities (at right), hold promise for new approaches to the problem of long-range detection and tracking of aircraft and ICBM's.

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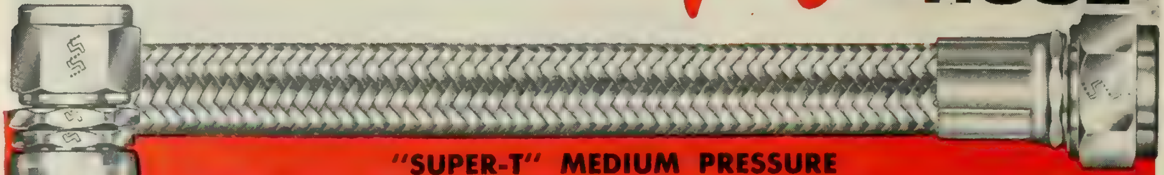

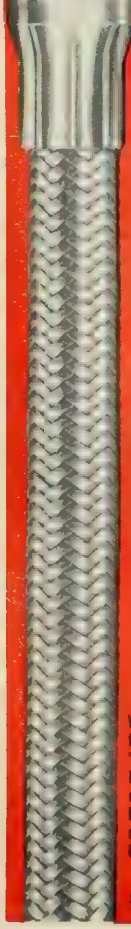

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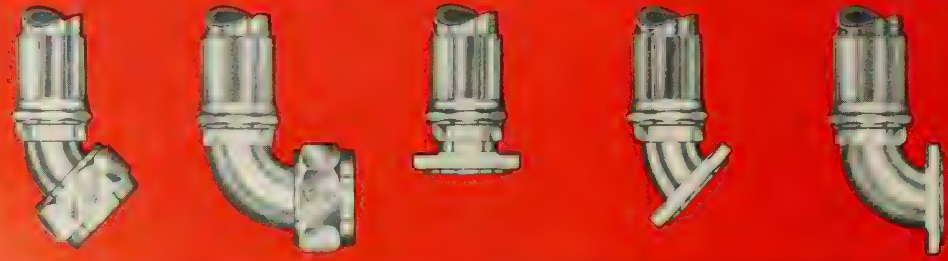

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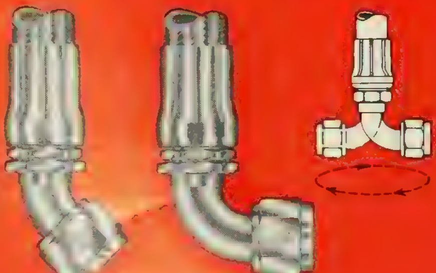

Designed for reliability and flexibility at temperatures ranging from −65 to 450 F, Stratoflex "Super-T" and Super "T-HP" Teflon Hose exceed the rigid requirements of MIL-H-25579 and MIL-H-8788 (ARP 604) respectively. The stainless steel braided cover hose and inner tube of Teflon has an operating range of 1500 PSI to 3000 PSI and is used to convey the following fluids: fuels, oils, acids, solvents, alcohol, high pressure gases, as well as liquid gas transfer service. Fittings are made from all corrosion resistant steel or a combination of both carbon steel and corrosion resistant steel. Assemblies are available with straight, 45° and 90° elbows. Other angles are available to your specifications.

*Teflon is a registered DuPont trademark

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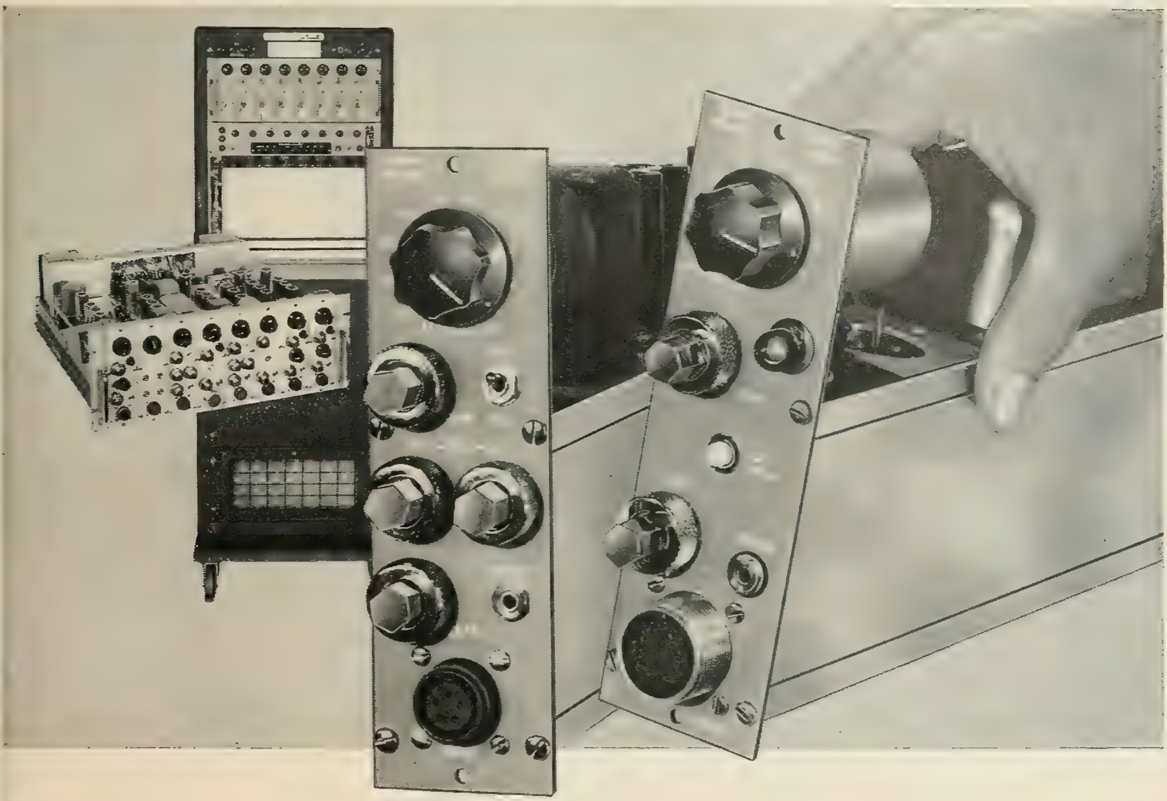

WITH the availability of these two new plug-in preamplifiers and associated MOPA, Sanborn 6- and 8-channel "850" oscillographic recording systems can now record an even *wider* variety of inputs — wherever *many channels* are needed in *minimum panel space,* with *no* sacrifice in system accuracy or reliability. The 850-1100A is a carrier amplifier-demodulator unit designed to work with resistance bridge, variable reluctance and differential transformer transducers. Attenuator, smooth gain, position and balancing controls are on the 2″ x 7″ front panel; input and output connections are provided at both front and rear. The 850-1500A is a chopper amplifier with floating input isolated from a floating output, capable of measuring low level DC-100 cps signals such as those from thermocouples and strain gage bridges. Design provides low noise operation, greater freedom from ground loop interference and high common mode rejection ratio. Required carrier excitation (2400 cps standard, 600, 1200 and 4800 cps optional) and chopper drive (440 cps) voltages are supplied by the 850-1900 MOPA, a dual-oscillator unit which can handle up to eight of each preamplifier.

SPECIFICATIONS

	850-1100A	850-1500A
Sensitivity	100 μv in gives 1 v at output	
Input impedance	approx. 2500 ohms	approx. 100,000 ohms
Output	±2.5v across 3300 ohms	±2.5 volts across 2500 ohms
Freq. response	−3 db at 20% of carrier freq.	0–100 cps, −3db
Linearity	±0.5% of full scale	±0.1% of full scale
Common mode performance		120 db for 60 cps, 160 db for DC with 5000 ohms unbalance in input
Noise		2 μv p-p over 100 cps bandwidth

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Ask your Sanborn Sales-Engineering representative for complete facts on all "850" system units — or write the main office in Waltham.

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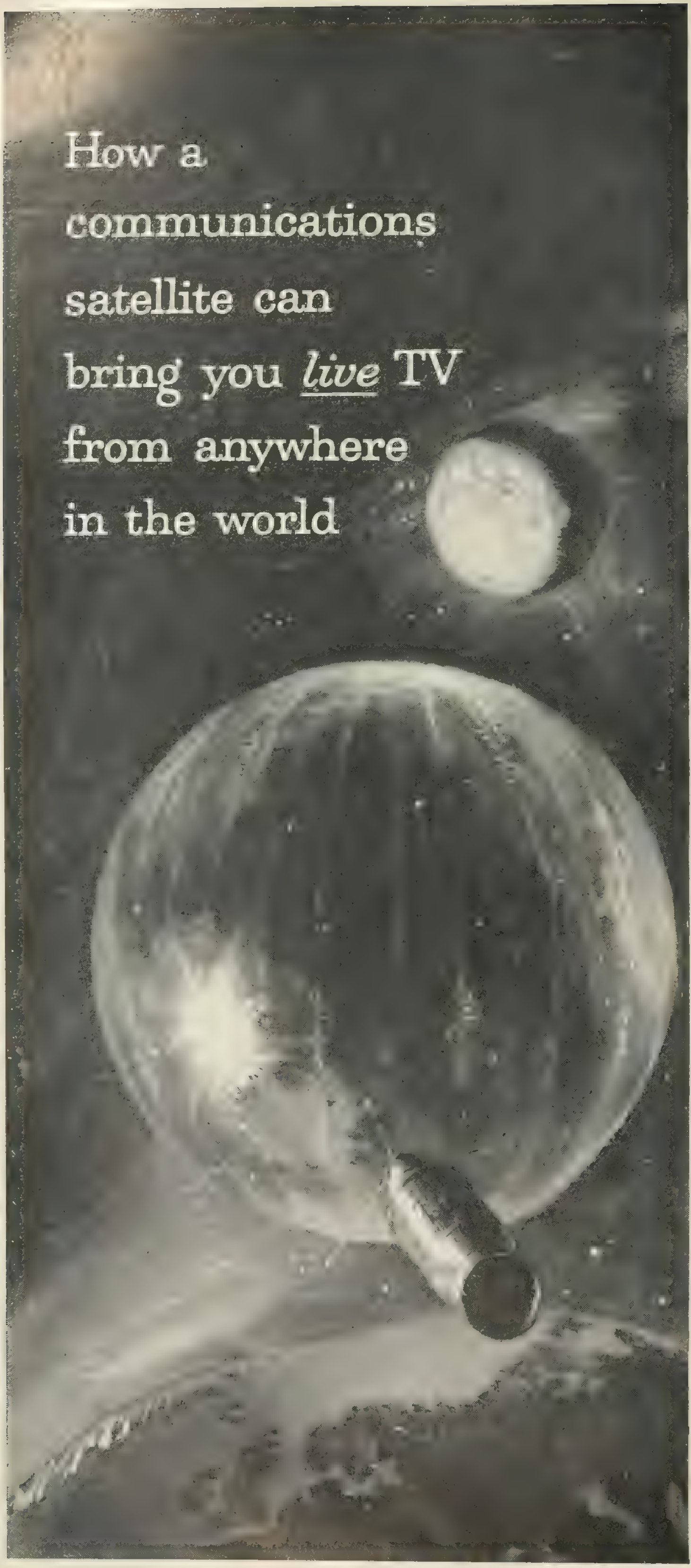

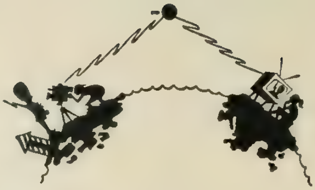

World-wide live TV, with no cable or radio relay costs, can develop from outer-space research by government and industry

Among the peaceful applications for scientific break-throughs being made in the study of outer space is a communications satellite.

Using inflated plastic satellites, boosted toward orbit by the Air Force *Thor* rocket, a global TV network could be established. TV signals would bounce to satellite and back to your station, giving you a front-row seat at events anywhere in the world. Cost should be a fraction of coaxial cables and microwave relays now used.

Practicality of *Thor* for this purpose is based on its demonstrated reliability. With Douglas responsible for airframe fabrication and assembly and test of the entire system, *Thor* has helped launch 84% of all payload weight put into space by the U. S.; is the key booster in the Air Force "Discoverer" firings; launched the first nose cone recovered at ICBM range.

Thor is another product of the imagination, experience and skills which Douglas has gained in nearly 20 years of missile development.

Foil-covered satellite, folded like a pocket raincoat, would balloon out in orbit as an inexpensive TV relay station

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AF Pushing for Big Solids

Industry expecting decision soon on feasibility contract for developing one-million-pound-thrust booster

by Jay Holmes

Washington—America may soon have a new entry in the race for space—a program for development of a million-pound solid-fuel booster rocket.

Maj. Gen. Victor R. Haugen, director of development planning, deputy chief of staff/development, U.S. Air Force, announced Nov. 5 that the Air Force plans "to let a contract very soon to demonstrate the feasibility of a rocket engine which will be twice as large as any other under development."

Thiokol's *Minuteman* booster is the largest solid rocket at present under development. Its thrust and other performance figures are classified. However simple physical calculations indicate that it could not be much less than 400,000 lbs. and might be more.

The *Nike-Zeus* booster, although not the largest rocket in size, is known to develop 450,000 lbs. thrust. Thus an engine twice as large as any other under development would have to approach the million-pound class.

Industry has greeted the development with enthusiasm. At least four major rocket companies have announced that they are capable of taking on the development of a motor of this size. It is believed that at least two other companies are interested. The "million-pound solid booster" was a major topic of conversation and conjecture in the industry suites at this month's American Rocket Society convention.

John Gustavson of the Advanced Concept Office, **Grand Central Rocket Co.,** outlined details for construction of a 2.4-million-lb.-thrust solid engine, which would burn 72 seconds at a thrust-to-weight ratio varying between 2.5 and 7.9. The booster, weighing 691,000 lbs., would be 90′ long and 12.5′ in diameter and would perform at a specific impulse averaging 265 seconds between sea level and the burnout altitude of the booster, he said in a paper read in the session on solid rocket technology.

Gustavson said six of these rockets, known as *Cronus*, could be clustered into a 14.4 million lb. booster, which he named *Novus*. The *Cronus* could operate, he said, with a second stage generating 650,000 lbs. thrust for 82 seconds and a third stage generating 100,000 lbs. thrust for 133 seconds. This configuration could lift a payload of 26,000 lbs. into a 300-nautical mile orbit, Gustavson calculated.

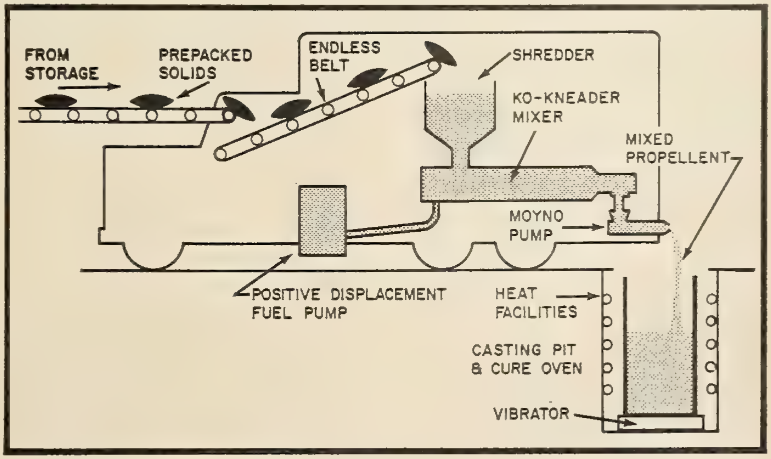
Thiokol, **Aerojet-General** and **Rocketdyne** also have indicated in recent weeks that they are capable of building boosters in the multi-million-pound range.

In comparing solid and liquid boosters, one must recall the much longer typical burning times of liquid-fueled rockets. For example, most large liquid rockets under development contemplate burning times of 180 seconds.

A truer measure of the size of a rocket is the total impulse, measured in pound-seconds. The Grand Central *Cronus* booster would have a total impulse of 172.8 million pound-seconds. This would compare in total impulse with a 180-second liquid rocket with an average thrust of 960,000 lbs.

At the Symposium on Advanced Propulsion Concepts, held in Boston last month by **Avco-Everett Research Laboratory** and the Air Force Office of Scientific Research, Dr. Harold Ritchey of Thiokol proposed a solid booster of 10 million lbs. thrust and 60 seconds duration. This would thus have total impulse of 600 million pound seconds, comparable to a liquid rocket generating 3 1/3 million lbs. thrust for 180 seconds.

Gustavson and other solid-fuel spokesmen maintain that a scaled-up booster can be developed in for less



CONTINUOUS MIXING process developed by Grand Central Rocket Co. for loading big solid-fueled booster rockets at the firing site.

time than required for liquids because solids have fewer parts. And, since development cost is largely dependent on the length of time involved, they argue that developing a large solid rocket is cheaper.

Last spring, the Air Force made a routine query of contractors as to what it would cost to demonstrate the feasibility of a million-pound solid rocket. The bids received varied from under $2 million to more than $6 million. M/R has learned that one of the under-$2-million bids contemplated a first static test 8½ months after the go-ahead.

However, the Air Force decided not to award any contracts at that time. Officially, the situation lay dormant until Maj. Gen. Haugen made his statement in a speech before the 12th annual national conference of the Public Relations Society of America at Miami Beach, Fla.

Gen. Haugen said the Air Force, which has been working with solid fuels since 1953, feels they "hold great promise for reduced costs" in addition to the often-cited advantages of instant reaction, long storage life and ease of maintenance.

• **Energy Rate**—Another advantage cited by the solid supporters is the higher rate of energy production in solid boosters, which enables them to better overcome the loss due to gravity. For example, in the Grand Central *Cronus* proposal, the thrust-to-weight ratio at takeoff would be 2.5. Subtracting the one G lost to gravity, the acceleration at takeoff would be 1.5 G, gradually rising to about 7 G just before cutoff.

The liquid rocket is limited by the weight of pumps and tanks to a maximum of 1.5, Gustavson declared. Thus the initial acceleration is less than 0.5 G. This gradually increases, he said, until its burnout acceleration is just equal to the burnout acceleration of the solid.

Thus, solid rocketeers assert, the total velocity increment is less for a liquid than a solid. They further maintain that this difference is sufficient to overcome the liquids' advantage in specific impulse and the somewhat lower dead weight of a liquid booster.

Thiokol's Ritchey maintains that the division of responsibility between solids and liquids for space now is just the opposite of what it ought to be, with boosters and lower stages liquid and solids in the upper stages.

Actually, he says, the higher specific impulse of liquid fuels can be used to better advantage in the upper stages, while in a booster specific impulse is not quite so critical a factor.

Ritchey points out that high-energy fuel systems and exotic case materials always are preferred, at least in early stages of their development, for upper-stage use. The same argument would lead to selection of high-energy liquid upper stages, he says.

Solid rocketeers concede the impossibility of turning their flames off and on again. But they say this is less important in a booster, which must lift a system into orbit before any other space mission can be performed.

The Air Force outlined its requirements for such a booster to contractors Nov. 10 at a meeting at Edwards Air Force Base, Calif. The meeting was attended by representatives of Thiokol, Aerojet, Rocketdyne, Grand Central, **Hercules Powder Co.**, **Atlantic Research Corp.** and the **United Research Corp.**, a subsidiary of **United Aircraft.**

A key to the manufacturing of large solid-fuel rockets is the continuous processing of propellant. For a booster solid would be too big to transport by rail or truck to the site. Thus on-site loading seems a logical alternative. This would require on-site processing. At least six companies are working on development of continuous processing methods.

Rocketdyne disclosed some details of its method in a statement issued at the ARS convention. The North American division says its process, known as "Quickmix," is expected to provide a high degree of mobility for manufacturing in the field and loading into large motors. Rocketdyne is applying the process to several propellant combinations under contract with the Manufacturing Methods Division, Air Materiel Command.

A "Quickmix" pilot plant, which has a minimum capacity of 500 lbs. of propellant per hour, recently was loaded onto a 30′ truck trailer and transported from California to Rocketdyne's solid propellant plant (formerly named Astrodyne) at McGregor, Tex.

In the process, ingredients are blended in a matter of seconds with only a small amount of material in the mixer at any given moment. The oxidizer is dried, sifted and ground before being dispersed in a liquid carrier.

Minor dry propellant ingredients are handled in a similar way. Liquid ingredients enter the system through a colloid mill for emulsifying with the liquid carrier. Where metallized propellants are required, the powdered metal also will be mixed with a liquid carrier, thus reducing the special hazards that come with handling of fine metal powders.

The streams of oxidizer and other ingredient in the liquid carrier are blended at high speeds in a small mixer. Because of the fluidity, mixing is accomplished rapidly with no appreciable heat buildup and a very low power requirement. The propellant forms immediately on contact of the binder droplets and oxidizer particles.

Rocketdyne says a Quickmix plant with a capacity of 5,000 lbs. per hour could be constructed and it would also be able to operate successfully at reduced rates. The plant and raw ingredients would be transported to the proposed firing site for the field loading of rocket motors larger than feasible to transport from plant to site.

• **Other methods**—Grand Central has developed a continuous mixer on a truck trailer. Propellant ingredients can be trucked to the site, mixed at leisure, loaded directly into the rocket case and stored until needed.

Thiokol, Aerojet-General, Hercules and **Olin Mathieson** are known to be developing continuous mixing processes. The problems have not all been solved. Several explosions have occurred in recent months during tests of these processes.

Next Week: Soviet Propulsion

Next week, Missiles and Rockets *presents another exclusive first—a complete and authoritative report on Soviet rocket propulsion systems.*

Donald J. Ritchie, one of America's top non-government experts on Soviet rocket and aircraft technology, gathered his material through a study of 120 textbooks and hundreds of periodicals in the Russian language. Ritchie, a project mathematician in the Research Laboratories Division, Bendix Aviation Corp., formerly was engaged in R&D work at Wright Air Development Command, Melpar Inc. and Crosley Division, Avco Corp.

Among the details outlined for the first time in Ritchie's comprehensive account will be the thrust level and other technical data for the Soviet ICBM's, Sputniks, Luniks and many smaller rocket systems.

M/R Surveys the Exploding Semiconductor Industry

Already a half-billion-dollar-a-year business, forecasts indicate the total will double in five years unless imports hit defense market . . .

by Charles D. LaFond

WASHINGTON—The semiconductor industry is experiencing a growth that resembles an explosion. Barely eleven years old, its future impact on the rest of the electronics industry cannot even be guesstimated. We are blinded by long-range market forecasts, business speculations, technological huckstering and research ballyhoo.

M/R estimates, based on an industry survey, indicate the total 1960 semiconductor market will approach $510 million: $295 million military; $215 million commercial. These figures represent a mean, for industrial estimates vary by about ±$4 million. But on one total—the 1965 estimated market—the figure was almost a unanimous $1 billion.

According to Dr. Frank Herman, **RCA Laboratories,** thousands of articles and responsible text books already have been published on semiconductor science and technology. Well over 150 commercial companies are now engaged in development and production of solid-state devices and more than 100 of these are American firms. (It has been estimated that nearly 35% of the world volume of currently published basic research in physics is in the solid-state area. Roughly, this is between 1500 and 2000 papers annually.)

He conservatively estimates that the total semiconductor-device output should overtake that of vacuum tubes by about 1962 in the United States.

• **The industry**—The accompanying chart contains most of the semiconductor manufacturers in the U.S. today and a list of the principal products of each by category.

For a rapid rundown of what some of the major producers are doing, the following summary has been prepared. The list is not intended to be complete, but it will indicate the trends of today—that is, the successful smaller companies are carefully expanding and the large manufacturers are engaged in an R&D marathon. Big or small, each is making technological headway.

Pacific Semiconductors, Inc., recently announced development of a "micro-micro diode" weighing 14.09 milligrams (a standard silicon diode weighs approx. 160 mg). According to PSI, the small size was achieved by a molecular bonding process. It was described as a chemical surface passivitation technique in which silicon crystal molecules are bonded with the protective-coating surface elements.

A relative newcomer to the field is **P. R. Mallory and Co., Inc.,** which will limit its efforts to single junction devices for the present. Developmental work and pilot production operations are nearly complete. Diffused junction silicon rectifiers will be marketed during 1960, but certainly growing pains will slow its mass entry into the field.

Philco Corp. is involved in almost all phases of semiconductor R&D and manufacturing; it has programs to develop packaging for severe environments, to increase power dissipation and increase maximum storage limit to 175°C, to improve fabrication techniques, to replace potting compounds in some devices with a process wherein no heat is developed.

According to a company spokesman, significant research is being directed toward new semiconductor materials which will make possible new physical phenomena. Magnetic-film memories for next-generation computers are being studied along with electroquenchable phosphors for low-cost computer elements.

Industro Transistor Corp., a manufacturer of high-quality PNP germanium alloy junction transistors only, expects to increase its product line considerably during the next six months with silicon mesa and power transistors, and silicon rectifiers. (It is interesting to note that Industro has experienced a management metamorphosis. Fiscal '58 and '59 showed successive deficits. During the last quarter of its current year, it has completely removed the deficit and showed an earning above taxes of $0.24 per share.)

Primary company research efforts are aimed at tunnel diode development and radical improvements in transistor environmental capabilities.

Transitron, Inc. has achieved a remarkable growth in the last few years. A manufacturer of semiconductor components only, it is currently a family-owned closed corporation. This December it will make a 1-million-share public stock offering.

Already a broad contributor to the semiconductor product field, **Raytheon Company** is investing much of its research in continued development of tunnel diodes and the avalanche mode transistor for high-speed switching.

The Semiconductor Div. of **Fairchild Camera and Instrument Co.** has concentrated on development and production of high-quality silicon transistors for ultra-high-speed switching. It recently introduced seven new types of transistors and some silicon devices for microminiaturized circuitry. Research programs are investigating new semiconductor materials, tunnel diodes, parametric diodes, microminiaturized modules, and devices using intermetallic compounds.

Hoffman Electronics Corp.'s Semiconductor Div. recently announced success in one of its R&D programs. It has developed automatic test equipment that speeds up high-low temperature operating "run-in" tests on Zener diodes by 700%. (Tests are designed to insure maximum stability and reliability.)

Texas Instruments has a complete line of solid-state components. A pioneer in the field, it produced one of the first demonstration solid state functional circuits. TI uses diffusion techniques with photolithographic processes to produce circuit "components" in a single semiconductor crystal.

Westinghouse Electric Corp.'s Semiconductor Div. is engaged in a sizeable research program. A large semiconductor producer, it is pushing its efforts for a better understanding of molecular electronics. By modifying the properties of solid-state material through a control of crystalline structure, a desired function can be achieved by the researchers without the need for individual components.

Westinghouse believes only an approach such as its molectronics can achieve the desired reliability, ruggedness, and low power consumption necessary for tomorrow's missile/space system requirements.

For more conventionally sized circuits, the company has been investigating cold-cathode type electron tubes using various semiconductors for electron emission. It recently announced successful use of silicon carbide in such a "transistorized" electron tube. Power requirements are negligible; current flow is low but adequate (of the order of 1 microampere).

Radio Corporation of America, General Electric, and **Hughes Products**—Semiconductor Div. are all large producers of semiconductor devices. Accordingly, each maintains a broad research effort: molecular electronics and thin-film circuitry, exotic metals, and the whole gamut of conventional solid-state components. Each has had notable success in the development of tunnel-diode circuit applications.

• **Transistor prices**—To understand the steady downward trend of transistor unit prices, a study of the development and subsequent production record of transistors is most revealing.

Initially, development costs were high for the first year following the **Bell Telephone Labs** invention of the point-contact transistor. As costs began to decline, the zone-refining process evolved and the junction transistor was conceived. Development costs again rose sharply and continued until 1952. The first real production began in 1952. It has risen sharply and almost linearly ever since.

In 1955, with the birth of the diffusion process and the silicon transistor, developmental costs again rose sharply. Only recently have they begun to taper off somewhat. Bell Labs estimates that the total 1955 production of transistors was approximately 4 million units at an average unit price of four dollars.

By 1960, production will be well over 100 million units and the average price will have dropped below two dollars. Production may level off at around 750 million by 1970 with a unit price near $0.70 or less. Rapid development and application of tunnel diodes and future breakthroughs can completely alter these estimates. Only time will provide all the answers.

It is also interesting to note that as a result of advances in diffusion technology, the semiconductor diode market should eventually equal that for transistors. Many feel it may even exceed the transistor market because of the diverse applications for diodes.

Major U.S. Semiconductor Makers

	Transistors							Diodes			Rectifiers			IR Detector Cells
	Germanium	Germanium Power	Photo	Silicon	Silicon Power	Switching	Tetrode	Germanium	Silicon	Zener	Germanium	Silicon	Solid State Thyratrons	
Aeronica Mfg. Corp.														X
Allis-Chalmers Mfg. Co.											X	X	X	
American Elite, Inc.								X						
American Rectifier Corp.								X	X			X		
Amperex Electronic Corp.	X	X	X					X	X	X	X	X		
Arco Electronics, Inc.									X	X				
Audio Devices, Inc.									X			X		
Avion Div., ACF Ind., Inc.														X
Axler Associates														X
Barnes Eng. Co.														X
Basic Controls Corp.														X
Bausch & Lomb Optical Co.														X
Baird, Atomic, Inc.														X
Bendix Aviation Corp.	X	X		X	X	X						X		
Block Assoc., Inc.									X			X		X
Bogue Elect. Mfg. Co.	X			X	X		X	X	X		X	X		
Bomac Labs.									X					
Bradley Semicond. Corp.												X		
CBS-Hytron Div.	X	X			X	X		X	X					
Cartriseal Corp.								X	X					
Centronix, Inc.														X
Clark Electronics Lab.											X	X	X	
Clevite Corp.	X	X			X	X		X	X					
Columbus Electronics Corp.									X			X		
Crystalonics, Inc.				X										
Delco Radio Div.	X	X												
Delta Chem. Works								X	X					
Dynamic Electronics, Inc.														X
Eastman Kodak Co.														X
Emerson Electric Co.														X
Erie Resistor Corp.								X						
Fairchild Semicond. Div.				X	X	X								
Fansteel Metall. Corp.									X			X		
Farrand Optical Co., Inc.														X
Ferranti Elec., Inc.									X			X		
Finney Co.								X	X					
Electronics Corp. of Am.														X
Flame Research, Inc.														X
GB Electronics Corp.														X
Gates Electronic Corp.												X		
Gen. Electric Co.	X			X	X	X	X				X	X	X	X
Gen. Instrument Corp.								X	X	X	X	X		
Gen. Nuclear Corp.												X		
Gen. Transistor Corp.	X		X	X		X		X						
Great Eastern Mfg. Co.	X		X	X	X	X	X	X				X		
Gulton Ind., Inc.	X			X	X									
Hoffman Electronics Corp.				X	X				X	X		X	X	X
Hughes Semicond. Div.	X			X		X		X	X	X		X		X
Hycon Mfg. Co.														X
I.T.T. Corp.									X	X		X		X
Industro Transistor Corp.	X													
Intercont. Electronics Corp.	X							X						
Internat'l Electronics Corp.	X		X		X	X								
Internat'l Electronics-Mullard								X						X
Internat'l Rectifier Corp.									X	X	X	X		
Intimex Corp.			X											

• **Transistor imports**—At least one cloud exists on the transistor market horizon. Japanese imports have been increasing steadily. According to David R. Hull, president of the Electronics Industries Association, Japanese sales have hit the entertainment-type transistor field to the tune of 25% of the total U.S. business. There is one Japanese transistor import for every 3.6 units produced here, he said.

The danger, he pointed out, is that this is the market that has provided manufacturers with the funds to carry out R&D in other areas.

It is also obvious, he said, that if they can make inroads on the market to this extent in three years, it stands to reason that the defense market will also prove vulnerable.

• **Development**—Just in developing what we now have—that is, without considering advanced research aimed at further breakthroughs—what will the expected industry accomplishments be in the next few years?

Standardization of designs certainly will be a primary target for advance. Refinement, simplification, and reduction of designs for broad application will continue.

Manufacturing processes and techniques can be improved. Progress in automation has been made but to keep up with requirements—quality and quantity—large-scale advances are needed. Improvements are needed to protect semiconductor surfaces. Currently this is an expensive process necessary to obtain intrinsic reliability in bulk semiconductors.

A better understanding of the uses of semiconductor devices is mandatory. New circuit techniques will aid greatly the rapid application of such devices to a vastly greater number of different equipment.

To expand the range of available (or obtainable) electronic properties, other intermetallic compounds must be rigorously investigated and exploited. Others can be used to fill the gap in meeting more environmental requirements.

We need better methods of measurement and control of impurities when an order of magnitude of parts per million is considered. Until proper methods are devised, the semiconductor industry will be based more on art than exact science.

Improved or even new methods of attaching mechanical components to semiconductors are needed. Production type plating, welding, and soldering techniques in current use often introduce impurities and other degrading efforts into the finished product.

	Transistors							Diodes			Rectifiers			IR Detector Cells
	Germanium	Germanium Power	Photo	Silicon	Silicon Power	Switching	Tetrode	Germanium	Silicon	Zener	Germanium	Silicon	Solid State Thyratrons	
Isomet Corp.														X
Kellogg Switchboard & Supply Co.	X													
Kemtron Electron Prod., Inc.								X	X					
Leeds & Northrup Co.														X
Librascope, Inc.														X
Lindly & Co.														X
Litton Ind.					X									
Macarr, Inc.												X		
P. R. Mallory & Co., Inc.				X					X			X		
Marstan Electronics, Inc.														X
Microwave Assoc., Inc.									X					
Minneapolis-Honeywell	X				X		X	X						
Motorola, Inc.	X	X		X	X	X			X	X	X	X	X	
North American Electronics, Inc.									X	X		X	X	
North Hills Elec. Co., Inc.										X				
Nucleonic Prod. Co., Inc.								X						
Ohmite Mfg. Co.								X						
Opad Elect. Co.									X		X	X	X	
Pacific Semicond., Inc.				X	X	X			X	X		X		
Perkin Eng. Corp.											X	X		
Perkin-Elmer Corp.														X
Philco Corp., Lansdale Tube Co., Div.	X	X		X	X	X		X	X		X	X		X
Pyramid Elect. Co.												X		
Qutronic Semicond. Corp.	X	X	X				X	X	X					
RCA, Electron Tube Div.	X	X	X	X	X	X		X	X			X	X	
Radiation Electronics Corp.														X
Radiation, Inc.														X
Radio Dev. and Research Corp.	X			X	X				X					
Raytheon Co.	X			X	X	X		X	X		X	X		X
Rectico, Inc.												X		
Rheem Semicond. Div.				X	X	X			X			X		
Sarkes, Tarzian									X			X		
Semicon, Inc.									X			X		
Semi-Elements Inc.	X		X	X	X	X		X	X					X
Servo Corp. of Am.														X
Shockley Transistor Corp.									X					
Silicon Transistor Corp.				X	X	X			X			X		
Solid State Prods.				X	X	X							X	
Sperry Rand Corp.				X		X			X			X		
Sprague Electric Co.	X													
Sylvania Electric Prods.	X			X	X	X		X	X		X	X	X	
Syntron Co.									X			X		
Technical Apparatus Builders					X			X	X		X	X		
Texas Instruments	X	X	X	X	X	X	X		X	X		X		X
Thermosen, Inc.									X			X		
Thompson Ramo-Wooldridge	X			X										X
Topp Ind., Inc.	X													
Transitron Electronic Corp.	X	X		X	X	X		X	X	X	X	X		
Trans-Sil Corp.				X	X				X			X	X	
Tung-Sol Elect., Inc.	X	X			X	X			X			X		
U.S. Dynamics Corp.				X	X			X	X		X	X		
U.S. SemiCond. Prods. Div.									X	X		X	X	X
U.S. Semcor										X				
Vickers, Inc., Elect. Div.									X			X		
Warren Components Div., El-Tronics, Inc.								X			X	X		
Westinghouse Elect. Corp.	X	X		X	X	X		X	X		X	X	X	X
Workman TV, Inc.	X	X										X		

Huge Solar Converter Used To Open New Hoffman Plant

Los Angeles—Power from "Big Bertha," the world's largest solar energy converter, was used to open the doors to **Hoffman Electronic Corporation's** new Semiconductor Center at dedication ceremonies here last week.

The $2-million plant will be used to conduct research and development of solid-state material devices.

Described as the largest and most advanced of its type in the world, the Center is the first designed to mass-produce solar cells. The facility is reported to be able to produce semiconductor materials with a purity of 99.9999999%.

Hoffman's production capacity will be more than doubled by the new Center. Annual sales potential is increased to approximately $35 million. Employment at capacity will be an estimated 2000.

'Who Says There's A Space Race?'

Dr. Eberhardt Rechtin, Chief of the Telecommunications Division, Jet Propulsion Laboratory, NASA, recently delivered an address before the Electric Club of Los Angeles on the subject "Who Says There's a Space Race?" M/R reproduces it here in condensed form.—Ed.

A race has certain required elements. There must be a reward, a significant achievement and an interested audience. And there must be at least one participant, not necessarily two. We can all think of examples of a single participant who is racing against time.

This being true, then there most certainly is a space race since we have one highly demonstrative participant, the Russians, and ample evidence of the achievements, rewards, and interest to the audience.

Let us then consider the race from the point of view of the Communist government and society of the USSR. They want a strong Russian Communistic society. They want to expand their sphere of influence. And they want an increasingly favorable economic situation for Russia.

There is not much question that the original Soviet missile program was a direct consequence of a military need to counter our Strategic Air Command. According to the Soviet scientists, it was no simple task for them to get their space program started. As a matter of fact, it apparently took several years.

According to one possibly apocryphal story, a very serious question was raised in the upper Soviet government circles as to whether or not the Soviets should launch space vehicles at all. Certain members of the Soviet government were very seriously concerned that such space activity might trigger the United States into engaging in this race of missiles and space.

• **The payoff**—Probably neither the Russians nor the Americans remotely guessed the prizes which the Russians would pick up as a result of their success.

Some of the prizes can be valued in cold cash. The Russians probably spent on the order of $500 million to launch the first several *Sputniks*. As a direct result, the Russian technical prestige took a large discrete jump upwards in the world market. Conservatively, this jump, based upon the size of the world market and the size of various governmental expenditures, meant a return on the world market on the order of $5 billion.

To illustrate:

Suppose that you were a civil servant in South America or in Asia choosing a contractor to build a bridge.

We will consider two cases. First, go back to 1954. You would probably consider obtaining your bridge from the United States, the United Kingdom, or perhaps, West Germany. It is unlikely that you would consider a Russian contractor too seriously. Now, let's go to 1958. The countries which immediately come to mind are Russia and the United States.

Well, the prize of technical prestige in obtaining more of the world market is relatively obvious. Another prize, very easily overlooked by us, is an advantage which is probably of even greater value to the Russian Communist leaders—the fact that the Russian people are understandably and justifiably quite proud of their new technical achievements.

It is probably no coincidence that the Russians began mentioning (and we began considering) coequal summit meetings just after the launchings of the *Sputniks*. It is now no longer Russia, Great Britain, and the United States as the three great powers, it is now Russia verses the West, even up.

• **What next?**—The Russians will most certainly continue in the space race, since this race very well meets the overall objectives of the Russian Communist society.

From the economic standpoint, it can be shown that certain types of space vehicles will more than pay for themselves. Both communication and weather satellites can be used to make money. The Russians, could, for example, set up a world-wide communication system considerably better and more reliable than our high frequency radio system in use today—then rent and control this system.

• **What to do?**—The United States at the moment is neither in nor out of the space race. We have made no declaration to accept the Russian challenge. We have no programs whose avowed intent is to close the gap between ourselves and the Russians. We have one or two programs whose hopeful intent is to try to keep the gap from getting wider. At the present time, one of the most remarkable features of the U.S. position is the almost complete lack of urgency in the space program.

The NASA budget is now somewhat less than what the United States pays to ship and store surplus wheat. Our space program is less than two percent of our defense budget. The space program costs less than ten dollars per year per U.S. adult or roughly one evening's entertainment per year.

On the other hand, we have not declared ourselves *out*, either, although in the last two years we have dropped six months to a year further behind in the process of organizing, re-evaluating, carving out paper empires, and fighting over who is going to be the boss to tell the professional what to do.

The results of continuing as we are were illustrated the other day in a meeting at JPL in which we were attempting to plan the missions for a set of space vehicles in 1961 and 1962. We went through the process of setting up a logical and technically sound program, only to be shocked at the end of our efforts to find that the first half of our fine program had already been done by the Russians.

A colleague last week remarked that the closer you get to the space program, the more of a sinking feeling you get.

Putting it in somewhat different words, continuing at the present level is largely a waste of money. At the moment, we are paying for the privilege of being the perfect straight man for the Russians. As Dr. Glennan has stated, "we cannot run second very long and still talk of leadership."

In a perfectly objective way, we should therefore consider the results of declaring ourselves out of this game. We might well save ourselves a great deal of embarrassment. We would have to yield the field to the Russians and admit that they are highly successful. What would hurt is that we would have to admit by inference that their reason for success, namely the Communist Society, might also be true.

We should also consider the results of declaring ourselves *in* the space race. It will certainly cost us more money than we are presently spending. We are going to need clearly defined goals, specifically, whether or not we intend to accept the Russian challenge. We will need facilities and priorities. We need a very hard-boiled look at past performance and a willingness to let the finally chosen professionals run their own race.

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For accurate firing, Titan and its subterranean steelwork crib must be kept in absolute alignment with the earth's center despite natural movements of the crust or nuclear shock. This AMF production engineer's problem was to build the shock absorbers AMF designed for the job. These are massive, pneumatic cylinders constructed of precision-fabricated, precision-fitted steel parts.

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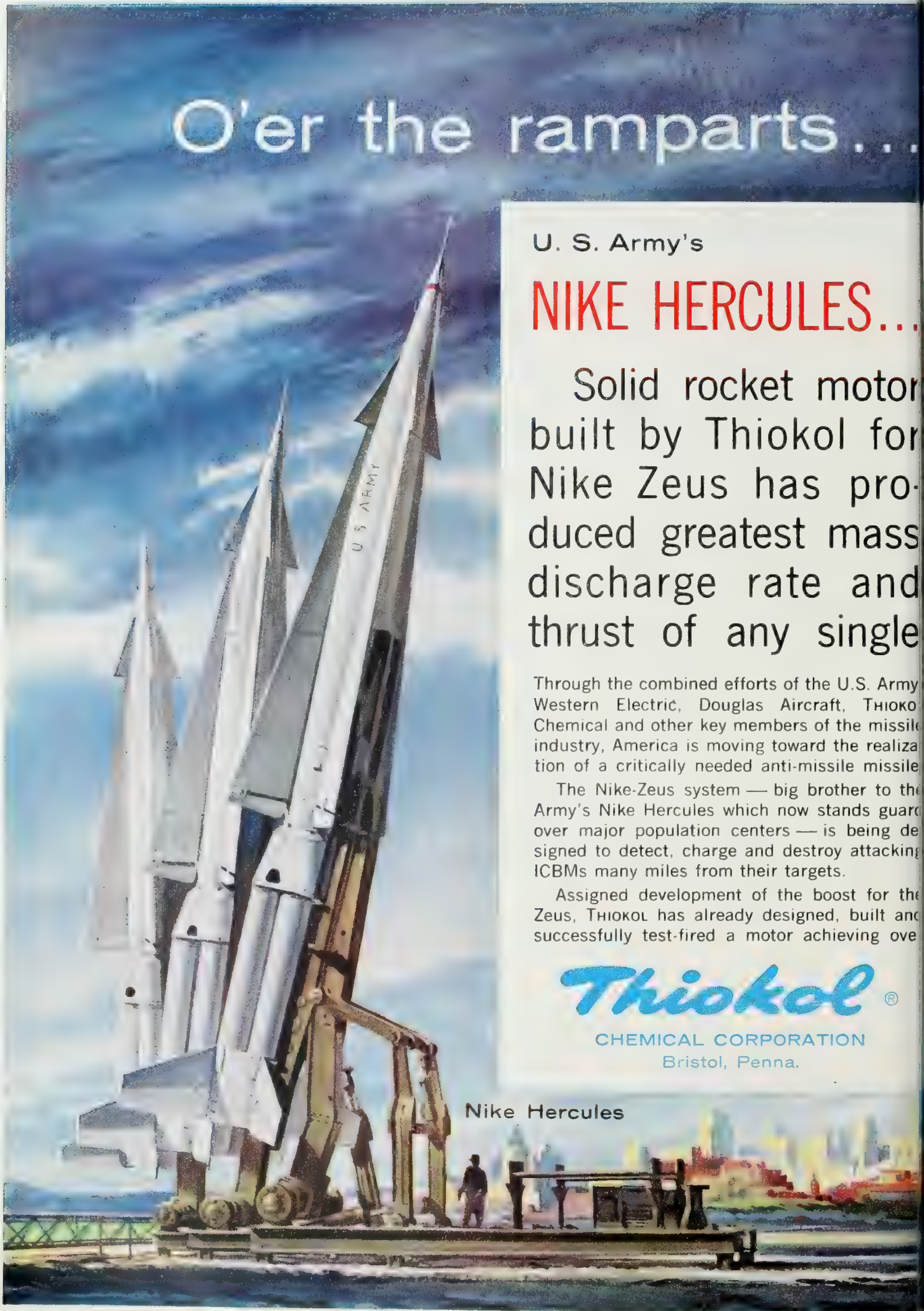

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thrust of any single

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The Nike-Zeus system — big brother to th Army's Nike Hercules which now stands guar over major population centers — is being de signed to detect, charge and destroy attackin ICBMs many miles from their targets.

Assigned development of the boost for th Zeus, THIOKOL has already designed, built an successfully test-fired a motor achieving ove

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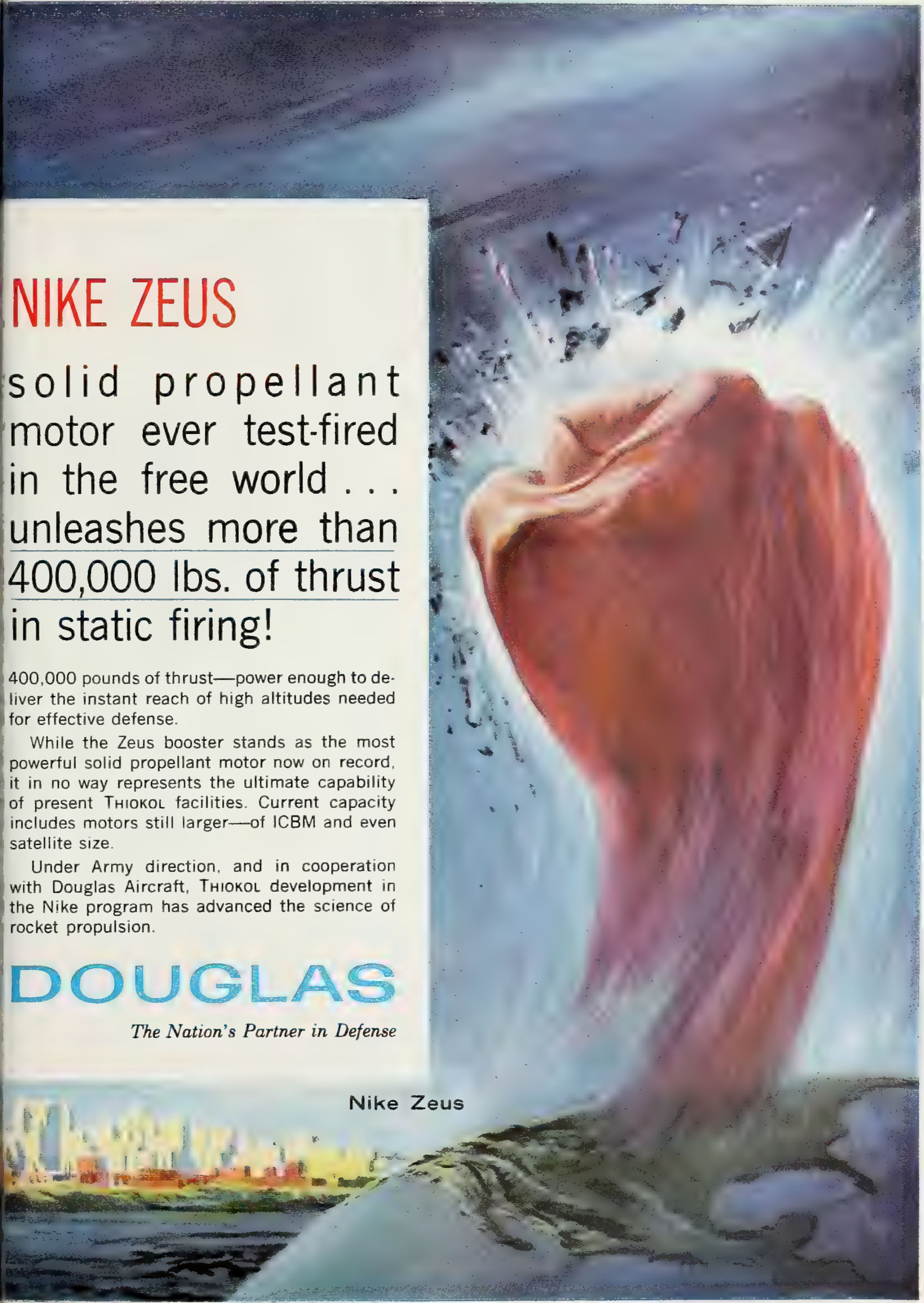

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400,000 pounds of thrust—power enough to deliver the instant reach of high altitudes needed for effective defense.

While the Zeus booster stands as the most powerful solid propellant motor now on record, it in no way represents the ultimate capability of present THIOKOL facilities. Current capacity includes motors still larger—of ICBM and even satellite size.

Under Army direction, and in cooperation with Douglas Aircraft, THIOKOL development in the Nike program has advanced the science of rocket propulsion.

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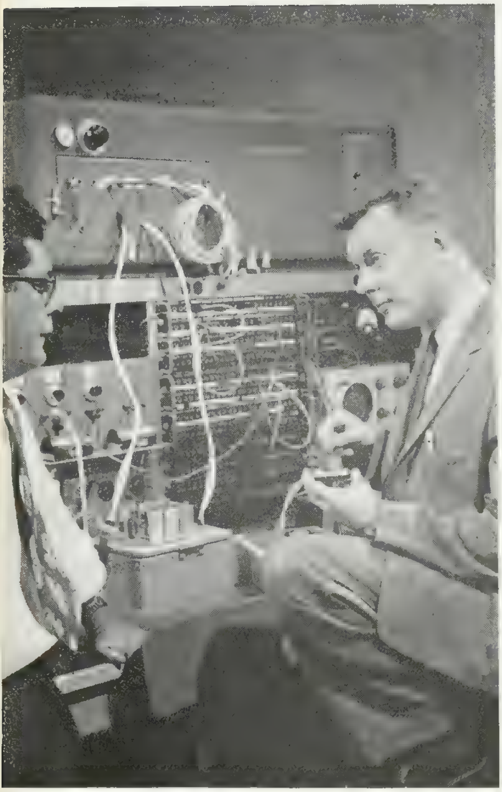

Transistorizing missile flight control systems by Lockheed scientists has meant significant reductions in weight and space requirements.

Flight Controls offers one of the most challenging areas of work at Lockheed's Missiles and Space Division.

From concept to operation, the Division is capable of performing each step in research, development, engineering and manufacture of complex systems. Rapid progress is being made in this field to advance the state of the art in important missile and spacecraft projects under development at Lockheed.

Flight controls programs include: analysis of flight data and sub-systems performance, design and packaging of flight control components, development of transistorized circuits, operation of specialized flight control test equipment, and fabrication of flight control prototypes. Other work deals with the design, development and testing of rate and free gyros; accelerometers; programmers; computer assemblies; guidance control systems; circuitry; and hydraulic systems and components.

In the flight controls simulation laboratory, mathematical representations of elements in a control system are replaced one by one with actual hardware to determine acceptability of specific designs. From these studies, Lockheed obtains information which is used in further refinement and improvement of final control systems designs.

Lockheed Missiles and Space Division is systems manager for such major, long-term projects as the Navy POLARIS FBM; DISCOVERER, SENTRY and MIDAS; Army KINGFISHER; Air Force Q-5 and X-7; and other important research and development programs.

ENGINEERS AND SCIENTISTS

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. Exciting opportunities exist for engineers and scientists to contribute to the solution of new problems in these fields. If you are experienced in one or more of the above areas or have background in related work, we invite your inquiry. Write: Research and Development Staff, Dept. K-29, 962 West El Camino Real, Sunnyvale, California. U.S. citizenship required.

Pre-flight check-out on final assembly on X-7 missile. The X-7 holds free-world's speed and altitude records for air breathing missiles.

One of Lockheed's test stands with dynamic thrust mount to simulate flight environment.

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Recorder Passes Flight Test

Miniature Ampex unit survives trip on missile and nine days in ocean; performs perfectly when retrieved

REDWOOD CITY, CALIFORNIA—A miniature tape recorder survived an Air Force missile flight and 9 days in the Atlantic Ocean, yet performed perfectly when retrieved from the water and tested with a new tape and tape turntable.

The recorder, Model MR-100, developed by **Ampex Corporation,** was enclosed in a plastic sphere on a *Thor-Able* carrying an instrumented nose cone. The recorder was thrown free before the cone struck the ocean. The plastic was strong enough to protect the recorder, yet light enough to allow the capsule to float in the water.

During its recording periods, all data telemetered from the nose cone during flight is stored. Temperature, pressure, stress, acceleration, and deceleration information is included.

The system contains two separate assemblies and weighs 20 pounds. The tape transport assembly contains the magnetic record heads, tape drive system, and system control circuitry. The electronics assembly contains the record and reproduce amplifiers and a reference oscillator used for timing. An interconnecting cable is used between the two assemblies. The entire system rides in a **General Electric**-developed instrumented sphere, 18 inches in diameter, made of polyurethane foam with a cover of ablative material.

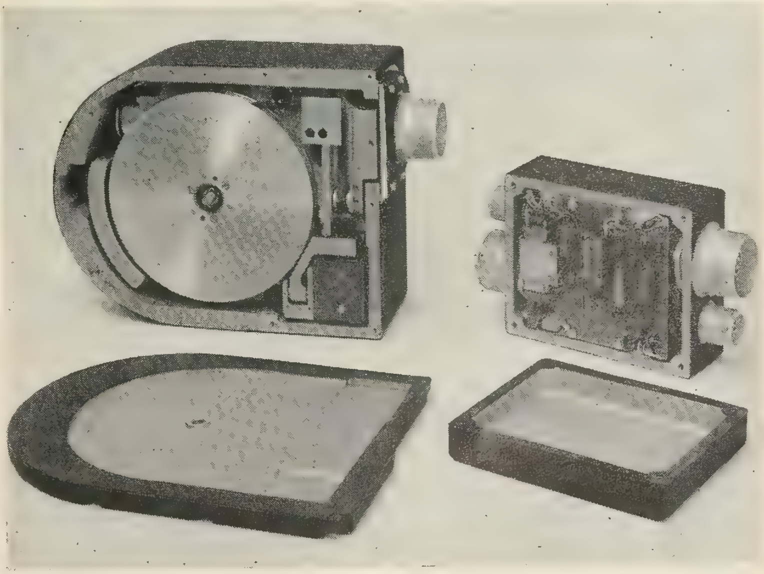
The complete system occupies less than one-fifth of 1 cubic foot. Capable of capturing information in a frequency band from 300 to 100,000 cycles per second, it will record two tracks of information utilizing parallel tracks on ¼-inch wide magnetic tape. The tracks are independent, each having its own record and reproduce amplifiers in the system's electronics unit.

The device begins recording on receipt of a command signal, continuing until expiration of the complete four-minute recording cycle. It then stops automatically. Depending upon type of operation desired, it does either one of two things: (1) Awaits another command signal, or (2) after 5 seconds, automatically reproduces the previously-recorded signal in reverse. It then stops and awaits another command signal to restart the transport in the recording cycle once more.

The recorder may be stopped at any time during the recording or reproduce portions of the cycle. At the completion of the reproduce cycle, the recorded data remains on the tape. Upon receipt of a command signal to begin another recording cycle, the existing signal is erased just before the new one is recorded.

The recorder provided nose cone information during re-entry period when attenuation of the radioed telemetry signals made ground reception impossible. This stored information was then reproduced in flight at a programmed time when telemetry attenuation no longer occurred.

The recorder's design presented problems of heat transfer and high-frequency vibration. A certain amount of heat is generated by the motors and tube filaments, and reducing the size of the equipment (or increasing the number of components per cubic inch of space) concentrates this heat in a small volume. Because the specified environmental ambient temperature was fairly high, it was quite difficult to obtain internal temperatures within the range required for reliable opera-



COMPLETE MR-100 occupies less than one-fifth of 1 cubic foot. Tape transport (left) and electronics assemblies (right) are shown with their covers removed.

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Featuring simplified design, the Midwestern Model 40 Series Servovalves have been tooled for production to meet existing and anticipated reliability requirements of military applications. Special effort has been made to lighten weight, improve hysteresis, decrease leakage and reduce susceptability to oil contamination.

Various configurations of the Model 40 are available for three-way or four-way service.

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Phase — 90° at 150 cps. max.
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RATED FLOW: To 5.0 gpm at 1000 psi valve drop.

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also manufacturers of Magnecord fine tape recording instruments

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tion of the components.

Although the tape transport assembly comprises the bulk of the system, it weighs only 14 pounds and measures 8-5/16 x 6½ x 3½ inches. Tape reels for the unit measure 5½ inches in diameter and can accommodate 1400 feet of tape which moves at 60 inches per second.

Components are mounted on a cast-aluminum chassis, which fits into a heavy cast-aluminum case. The case not only protects the operating mechanism from the external environment, but doubles as armor in protecting the tape during impact. The case and chassis are constructed so that if the mounting bosses on the chassis shear under impact, the raised portions of the chassis will come in contact with the case before the reels are crushed.

Embedded in the chassis are the three tiny motors for the system. There are two torque motors for the tape reels and a constant-speed motor which drives the tape at a uniform velocity.

Heart of the recorder—the magnetic record heads—is potted in a steel block, with centerline pivot bosses to locate them in a precision-machined thick-walled aluminum mounting box. The box, in turn, is enclosed by a close-fitting mu-metal container with a removable lid for tape threading. This provides double shielding against external magnetic fields.

With the exception of the control circuitry for the tape transport, all the circuitry is a part of the separate electronics assembly. The assembly contains, in addition to duplicate record and reproduce amplifier circuitry, a bias and erase oscillator and a crystal-controlled 93-kilocycle reference-signal oscillator.

To meet the temperature range specifications for the system of –55°C to+70°C, silicon transistors were selected. Other components such as a potentiometer, toroidal inductor, tantalum capacitors, and miniature resistors, were chosen for compactness and are mounted on etched boards. The etched boards fit compactly into the electronics case and are rigidly attached to a cast web. An inner mu-metal container shields the reproduce electronics. The complete assembly with covers installed weighs 6 pounds; measures 8½ x 4 x 3¼ inches.

As with any 60-ips tape transport, the inertia of the tape reels during starting and stopping is a basic problem. To obtain a 2-second start time, the lightest possible reel was required. Yet vibration and impact survival required great strength, so special reels were designed with tapered, aluminum flanges, precision-turned to 0.062-inch at the outer edges.

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Ice in the air intake of the North American "Hound Dog" could seriously hamper this missile's performance after launching from the wing of the Boeing B-52G. To prevent the formation of ice during strategic air attack in freezing weather conditions, this air-to-ground missile is equipped with an electrothermal metal-clad de-icing and anti-icing system made by B.F.Goodrich. It's a new application for B.F.Goodrich Cladheat and another forward step for B.F. Goodrich, the nation's leading producer of aircraft de-icing systems. For full information about B.F.Goodrich metal-clad, pneumatic or heated rubber de-icers, write: **B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MR-119A, Akron, Ohio.**

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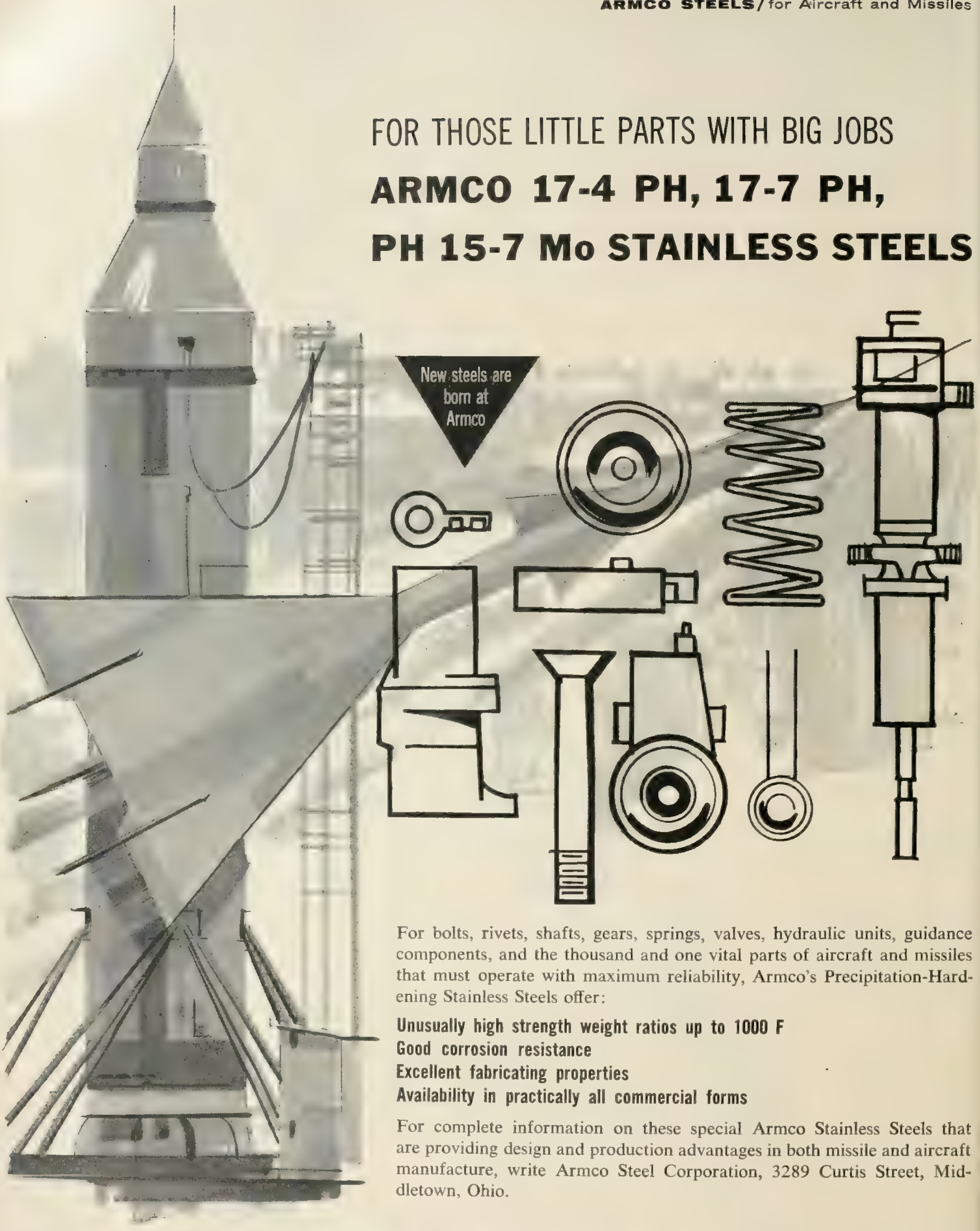
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propulsion engineering...

By JAY HOLMES

Which big liquid booster is better . . .

the *Saturn* or the so-called *Nova*? Both will develop about 1,500,000 lbs. of thrust. Both will have comparable burning times. Both will do about the same job.

Sam F. Iacobellis of **Rocketdyne** compared the two boosters on the basis of reliability, availability, performance and cost and came to the conclusion that neither the Rocketdyne single engine nor the ABMA *Saturn* cluster has a clear-cut advantage in all four respects.

Early reliability and low cost . . .

are advantages of the *Saturn* cluster, Iacobellis said in a paper at this month's American Rocket Society convention. But the single engine has higher ultimate reliability and greater performance. Iacobellis adds that the ultimate reliability of *Saturn* can be made competitive by adding a ninth spare engine.

For early availability and low cost (important) *Saturn* will be preferred. For performance and ultimate reliability, the *Nova* will get the nod. Furthermore, the big single engine is capable of being clustered into a booster with 6 million lbs. or more of thrust.

Reliability increases by about 20% . . .

on adding a spare to an eight-engine cluster, Iacobellis calculates. For example, assuming an 0.95 reliability for the single, smaller engine, an eight-engine cluster has about 0.67 reliability. If one spare is added, the reliability becomes about 0.82.

The Rocketdyne engineer also plots reliability of the engine against time for the single chamber, the eight-engine cluster and the cluster with a spare. To reach an 0.70 reliability figure, the *Nova* needs just under three years of testing. *Saturn,* which began in late 1958, would reach 0.70 reliability after about 22 months.

Cost of *Saturn* is lower too . . .

if we assume that only 50 boosters are required. Iacobellis figures that for this number the clustered booster would cost about 70% as much as the single engine. However, if many more of the engines are desired, the cost per unit of *Nova* drops below that for *Saturn.*

Department of Defense sources have estimated that the cost of 50 *Saturns* will be something over $800 million. Thus it follows that it will cost at least $1.14 billion to develop 50 single-cell *Novas.* This would supply 20 engine systems for vehicle development and six engine systems per year for five years of operational use.

On performance, *Nova* gets the nod . . .

because it can incorporate the latest developments in liquid rocket technology, while a cluster must make use of off-the-shelf engines. For a three-stage vehicle having a sea-level thrust of 1.5 million, Iacobellis assumes a 30,000 lb. payload can be delivered over an 8000-nautical mile range.

For the cluster, he assumes a 23,000-lb. penalty because of differences in the state of technology.

Ultimately, *Nova* will be more reliable . . .

than the *Saturn* cluster. Iacobellis' graph indicates the crossover point is about four years after the start of development, at which time the reliability of each engine is about 0.94. *Saturn's* reliability curve levels off about this time and doesn't rise much above about 0.95 unless a spare engine is added. For *Nova,* he calculates about 0.99 reliability after 6½ years.

If we plan to use these boosters to lift manned vehicles into orbit, ultimate reliability can be a rather important factor.

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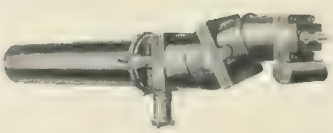
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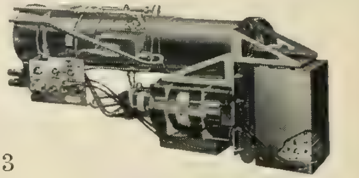
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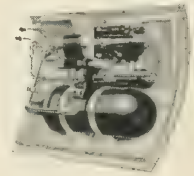
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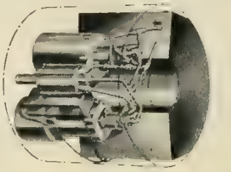
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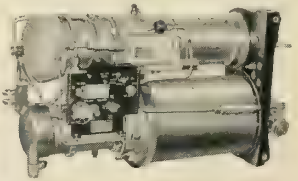
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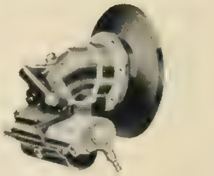
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Radar Operational Simulation Keeps Navy on Continual Alert

Servonics device already operational with the Navy supplies realistic blips, could be used in solving tactical problems

by William E. Howard

WASHINGTON—Much depends today upon a radarman's reflexes.

In the increasingly complex "man-machine" relationship, his ability to make a split-second interpretation and identification of blips on a scope is all-important in the Nation's defense system. On him hangs the crucial time factor to set in motion the vast U.S. retaliatory forces to combat a surprise Red attack.

As the Cold War arms buildup moves implacably onward, with a hot war always an imminent possibility—yet seemingly remote—military units are hard put to keep the reflexes of these key human operators tuned to peak efficiency. With a nuclear-war response time measured in minutes, even a second's inattention could be fatal to a city—the Nation.

For thousands of radarmen aboard ship, on patrol planes, in the outposts of SAGE, the DEW line, and soon, BMEWS, boredom is an insidious enemy. So is the familiar. Long hours can drone by for some without even a passing seagull to command their attention. In training exercises, no matter what pains are taken to create combat-similar conditions, the operator still knows it is make-believe.

Lacking have been the elements of surprise and urgency—the sudden bowel-stabbing realization that the fast-moving targets flitting across the scope may actually be an enemy attack: the real thing.

Now, however, the Navy has a device which, with the flip of a switch, can inject this much-needed realism into the radar of a ship or task force at any moment of the day or night. Called the AN/SPS-T2 and developed by **Servonics Inc.**, of Alexandria, Va., the device reproduces signals very closely resembling those appearing on a scope in a real enemy air attack.

It is already operational with the fleet. Servonics has produced 30 of the instruments and holds Navy contracts for 135 more. It appears from company-sponsored studies that the technique of simulation used may help solve air defense training problems by minimizing the man-machine problem in today's complex weapon systems.

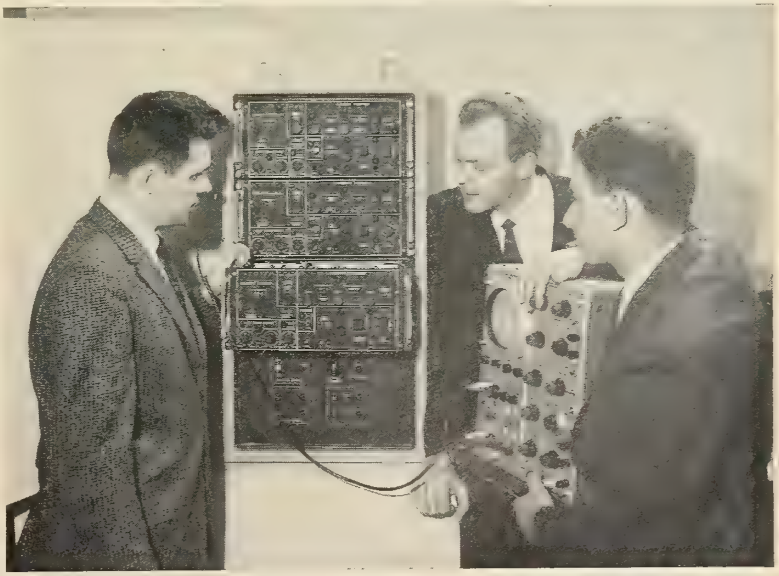
- **Versatility**—Originally conceived as strictly a training aid, the target simulator could be utilized to solve operating radar problems.

In addition to bombers and fighters, the company says, the device can simulate jamming from countermeasures and the signals can even be modified to reproduce missiles coming in at 17,000 mph. It thus is a potential trainer for BMEWS personnel as well as other military defensive units.

Aboard ship the AN/SPS-T2 can activate the entire weapon system permitting simulated targets to be mixed with the live targets simultaneously on height-finding, air search and surface search radars.

Advantages in this technique, as enumerated by Servonics, are:

- The operations officer can inject "ghosts" into sector search indicators at will to test the proficiency of radar operators in detecting unknowns.
- Ground control intercept maneuvers can be practiced without actually putting planes in the air. With closed loop simulation, pilots can watch the mission of the ground controller—thereby developing confidence between the pilot and the operator.



COMPACT RADAR simulator now in Navy use to keep radarmen on the alert was designed by Alex Long, center. Device may be used to train anti-missile batteries.

A SPECIAL KIND OF POSITION FOR SPECIAL KIND OF MEN

To help meet the urgent and continuing problems of national security, RCA has created an Advanced Military Systems Department at Princeton, New Jersey. There, in an atmosphere of complete intellectual freedom, men of a very special kind are engaged in highly sophisticated analysis and study of our national defenses—present and future—and how they can be made most effective to meet any future enemy capability.

THE POSITION—Studies conducted by the RCA Advanced Military Systems Department are of the broadest scope and cover such diverse areas as physical and engineering sciences, military science, economics and geophysics. Accordingly, each member of the technical staff may select his own area of work. The only requirement: results must have a direct application to problems of national defense.

Each staff member is provided with every opportunity, facility and detail of environment to use his creative and analytical skills to maximum advantage and at the highest level. He has no responsibility for administrative details. He can call in any specialists he may need. He has full access to all available information—military, academic and industrial. Furthermore, specialized research projects and laboratory work can be carried out at his request by other departments of RCA.

THE MEN—The men who form the technical staff are a group of mature scientists and engineers. They are accustomed to responsible positions in industrial research, advanced development, or systems planning. Most of them have an extensive background in the broad fields of electronics, vehicle dynamics (space, marine or terrestrial), physics (astro, nuclear, or plasma), or operations research (military science). All are men who enjoy seeing the fruits of their work have a far-reaching effect on the defenses of the country.

THE LOCATION—Princeton offers unique civic, cultural and educational advantages. The RCA Advanced Military Systems Department itself occupies a new, air-conditioned building on the quiet, spacious grounds of RCA's David Sarnoff Research Center.

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• Data handling capability of the ship's Combat Information Center can be increased through training of the team to cope with multiple high-speed unknown targets while reporting positional data.

• With several ships in fleet maneuvers, offset coordinates of each ship position relative to the target are measured by the simulator. The attacking targets are simultaneously cut on to fly courses, allowing each ship to receive the target complex as it would be viewed normally by their own radar.

• In the event a real target is wiped off the scope by interference or countermeasures, the simulator can inject an artificial signal to track the target from its last known position. Simulation of noise also permits training of operators to "see" through radars with a relatively high noise level.

The AN/SPS-T2 permits a form of tracking from air search radars and allows training in the correlation between air search and height finding radar data.

A single AN/SPS-T2 in a 14-cubic foot package generates six radar targets. However, the units can be hooked up in parallel to give the position, course, speed, altitude, turn rate and other data of as many as 30 targets. The simulator also reproduces relative motion of the target to ship, clutter, fading and range attenuation.

• **Started in 1956**—Designed to operate with all radars presently in the fleet, targets are generated by the simulator through manually manipulated knobs on the front panels of three of the four system cabinets. One unit provides information which is common to all the targets. It also is the source of the target video signals and antenna positioning signals which are supplied to the PPI and RHI indicators in associated radar systems.

The trainer is the brainchild of Alex Long, 32-year-old president and head engineer of Servonics, which was founded just four years ago this month. The company began developing the device back in April, 1956, under Navy sponsorship. Given a year to come up with a prototype, Long's team produced one in six months, and the Navy promptly ordered two more.

In early 1958, the simulator was subjected to fleet evaluation and in June of that year Servonics received a production contract in excess of $2 million.

It was aboard ship that the broader applications of operational simulation were realized. Now the company sees the AN/SPS-T2 as a prime weapon in the Cold War—keeping the Nation's front-line defenses in perpetual chips-are-down readiness.

ARS Abstracts

More Papers from the Recent Annual Meeting

WASHINGTON—The 14th annual meeting of the American Rocket Society held here Nov. 16-20 produced a number of significant papers in all areas of missile/space technology. M/R published many last week. Here are more:

Bio-Instrumentation

Objectives of Bio-Instruments, Albert W. Hetherington, Air Research and Development Command, U.S. Air Force, Andrews AFB, Md.

The author discusses the overall philosophy of bio-instrumentation. Specific goals discussed are the collection of scientific biological information, the monitoring of the status of the astronaut and the making the space-man's non-conscious and non-voluntary bodily status indicators a part of various control loops in the space vehicle. (ARS 930-59).

Biological Monitoring of Space Flight, Maj. Cloid Green, Aerospace Medical Center, Brooks AFB, Tex.

The paper discusses three phases of biological monitoring of space flight: the gathering of data from animals in order to delineate problem areas; the providing of a proving ground for the techniques under development; and the providing of protection and/or assistance for the human pilot. (ARS 931-59).

Instrumentation of Nervous System for Studies of Behavior, W. R. Adey, M.D., Univ. Calif. at Los Angeles, Los Angeles, Calif.

After presenting a history of brain mechanism study, the author discusses the results of tests monitoring brain regions in correlation studies of behavioral states, the special relationship of the temporal lobe to behavioral performance, the techniques of implantation of brain electrodes, required characteristics in amplifiers and recording systems, data reduction and computing, and self-stimulation techniques in behavior studies. (ARS 933-59).

"Space Canaries":—Implicit Biological Monitoring, Alfred Breckler, M.C., Leslie Kaeburn, Ph. D., Ben. L. Ettleson, A.B., and David W. Douglas, A.B.

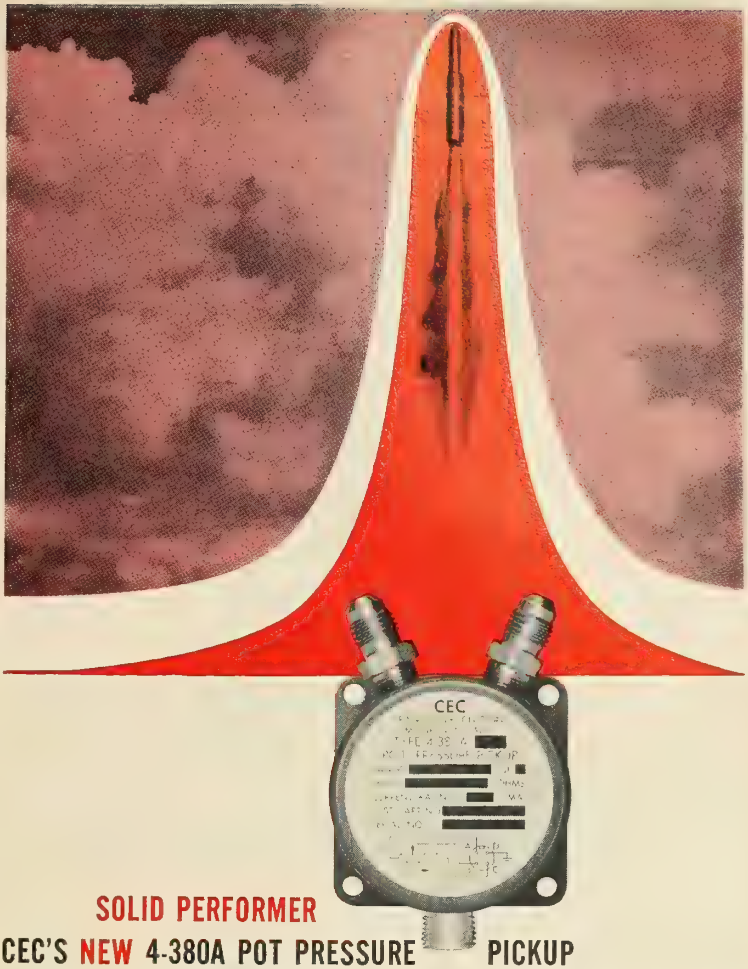
The authors discuss biological research with animals in preparation for manned space flight. Specific subjects discussed are: difficulties in human and animal instrumentation; a history of feasibility experiments, surgical procedures, feasible parameters for radio transmission, and possible applications of animal research in the space program. (ARS 925-59).

Thrust Orientation Patterns for Orbital Adjustment of Low-Thrust Vehicles, Harold Brown and J. Richard Nelson, Flight Propulsion Laboratory, General Electric Co., Evendale, O.

The authors discuss the use of low-thrust propulsion systems to adjust a space vehicle's orbit. The paper covers the characteristics of a space vehicle's orbit and environment in cislunar space, the desired changes in orbit possible with low-thrust rockets, and the various types of missions in which low-thrust rockets can be useful. (ARS 955-59).

Differential Correction Experimentation with the Low-Eccentricity Geocentric Orbit, L. G. Walters, S. T. Van Sant, J. D. Enright, and L. Saskin, Aeronutronic, a

(continued on page 43)



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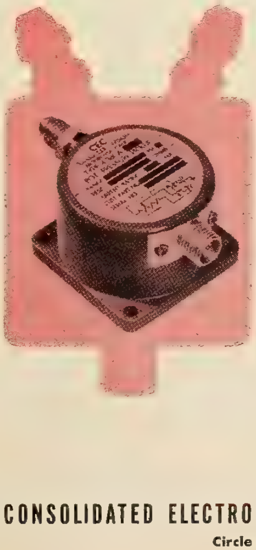

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• **Cape Canaveral, Fla.**—A **Lockheed** *Polaris* roared more than 900 miles down the Atlantic Missile Range Nov. 20 and landed near the predicted impact area near Puerto Rico. It was the second successful shot in the 900-mile test series.

It was followed on Nov. 24 by a "routine" test launching of a **Convair** *Atlas*.

• **Vandenberg AFB, Calif.**—The Air Force placed the eighth *Discoverer* satellite into a 120 to a 1000-mile polar orbit. But Air Force and Navy recovery teams again failed to recover a capsule dropped from the orbiting satellite. The capsule is believed to have plunged into the Pacific near Hawaii.

• **Washington**—The Atomic Energy Commission created an Aerospace Nuclear Safety Board to look into possible radiation menaces that might result from the use of nuclear-powered rockets. The board also would watch over development programs for nuclear ramjets and aircraft.

• **White Sands, N.M.**—A 31-year old airman—Capt. Joseph Kittinger—parachuted from the fringe of space, setting a new record. Kittinger jumped from the gondola of a balloon 76,400 feet over the desert. He plummeted 12,000 feet at speeds reaching 450 miles an hour before he opened his 28-foot parachute.

• **Los Angeles**—Missiles and space-related business accounted for 43% of **North American Aviation Inc.'s** sales in the FY which ended Sept. 30—compared to 20% in 1955. The company reported sales for the year topped $1 billion—a 16% increase over 1958's $904 million and second only to its record 1957 sales. Net earnings were $30.7 million, equal to $3.80 a share, against $26.7 million, or $3.34 a share, for the previous year.

• **Washington**—The Aerospace Industries Association told the Labor Department a redetermination of aircraft minimum wages might increase labor costs by as much as $100 million annually—thereby inflating defense procurement costs. AIA also said such action would give labor unions an effective weapon when wage reopening starts next year because it would tend to increase wages beyond rates agreed to in collective bargaining.

• **Washington**—Declaring space exploration will require increasing support from the military, ARDC Commander Bernard A. Schriever said the United States "cannot afford to concentrate solely on scientific explorations in space, and ignore its vast extension of the air as a theater of military operations." His statement was in direct opposition to Eisenhower Administration policy. Following the switch of ABMA to NASA, the President said he could not see "any reason why we should be using or misusing military talent to explore the moon. This is something that deals in the scientific field . . ."

• **Washington**—Additional funds were released by DOD for continued production by **The Martin Co.** of the Tactical Air Command's *Mace*. The Air Force said the total amount of the production program will now be about $100 million.

270 Watts Generated From Rocket Exhaust

An experimental thermionic generator tube which weighs 3½ pounds and slips like a sleeve over a flame tube has produced up to 270 watts from the exhaust of a solid rocket motor.

Developed jointly by **Radio Corp. of America** and **Thiokol Chemical Corp.**, the lightweight device in tests has proven to be efficient and feasible. Engineers of the two companies report that during powered flight, the tube's output could operate missile or space vehicle guidance, steering and telemetering packages—thus removing the requirement for heavy chemical batteries, increasing vehicle payload.

Resembling in operation a conventional two-element electron tube, the cathode of the thermionic generator is formed by the inner wall of the hollow cylinder, which is in contact with the hot exhaust. The outer wall forms the second electrode. Cesium vapor between the walls becomes ionized upon heating and transmits electrons to the outer electrode.

Industry on the Move

An astronertial and inertial guidance research center costing $4 million is being built by the **Nortronics Division** of **Northrop Corporation** . . . Near Dallas, **Temco Aircraft Corporation** is constructing a radiation systems laboratory . . . **Corning Glass** has formed a ceramic department to make parts for the electronic industry . . . **Tridea Electronics Inc.** has moved into a new location at South Pasadena, Calif.

New Liquid Hydrogen Facility

THIS UNIT with a capacity of more than 25,000 liters of liquid hydrogen per month is operating at Tonawanda, N.Y., laboratories of Linde Company, division of Union Carbide Corp. It turns out fluid with less than 2 parts/million impurities.

EXPLORE NEW AREAS AT IBM IN COMPUTER SYSTEMS

Now under development at IBM are new and unusual electronic computing systems that will greatly strengthen man's control of his environment. In one project, for example, advances in acoustics, oceanography, and information theory are being coordinated to yield a data system that will sentinel the ocean's depths. Another group is applying a computer's logic and computational capabilities to analyze, correlate, and identify input signals to data acquisition systems. In the late development stage is an extremely high-speed, large-capacity computing system which will automatically handle the large volume of detailed records and communications required by a nationwide sales operation. To staff such efforts, scientists, mathematicians, and engineers of vision are needed.

IBM's rapid expansion provides many opportunities for you to advance—either through technical achievement or engineering administration. You may work independently or with a small team, and you can choose your assignments from a broad range of research and development areas. Specialists of many different backgrounds are available to assist you in your work. This is an excellent opportunity for a scientific or engineering career that combines maximum growth potential with job stability.

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- Magnetics
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QUALIFICATIONS: B.S. or advanced degree in Electrical or Mechanical Engineering, Physics or Mathematics—and proven ability to assume a high degree of technical responsibility in your assignments.

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Planning and logical design of solid state computers, input-output systems, and peripheral equipment. Knowledge of digital systems required with experience in transistor circuitry and switching techniques.

Analysis of ferrite "memory" and buffer systems and design of new high-speed configurations, including drive and addressing circuitry, for advanced solid state data processing systems. Familiarity with digital computer systems and magnetic core "memory" design.

Solutions of real-time control problems with digital techniques; mathematical analysis of navigation and fire control systems, ray tracings, and signal cross-correlations.

Application of information theory to signal processing. Familiarity with signal cross-correlation techniques, statistical data processing, sampled-data control theory, analog-digital data processing techniques, signal propagation, and beam formation. Naval experience required in at least one of these specialties: sonar, fire control, ASW, navigational systems, signal processing.

Investigation of new computer applications and techniques, based on observation and analysis of customer needs; establishment of broad systems concepts, assisting in both logic and machine design. Experience required in digital computer applications, technical organization of a medium or large machine installation.

Circuit design of advanced data processing systems and input-output equipment, working closely with logic designers. Experience required in design of arithmetical control and switching circuitry to reduce logic diagrams to component counts for cost-estimating development.

Application of transistor-diode logic to develop advanced circuitry; review of new circuits for possible use in digital control systems, defining basic techniques for improving performance characteristics.

Laboratory facilities are located in Endicott, Poughkeepsie, Kingston, Owego, and Yorktown Heights, N. Y.; Lexington, Ky.; and San Jose, California.

For details, write, outlining background and interests, to:

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ARS Abstracts

(Continued from page 39)

division of Ford Motor Co., Newport Beach, Calif.

The paper discusses a differential correction procedure inclusive of special perturbations which has been developed especially for the low-eccentricity orbit. The procedure has, in previous experiments, determined orbit in less than one minute of IBM-709 machine time. (ARS 960-59).

Optimum Re-entry via a Variable Control Force, F. J. Marshall, Institute for Systems Research Laboratories for Applied Sciences, Univ. of Chicago.

The author discusses the reduction of harmful re-entry affects by allowing the vehicle to choose its velocity for a given density by control forces. The four control systems considered are: a thrust controlled radiating body; an aerodynamically controlled radiating body, a thrust controlled, non-radiating body, and an aerodynamically controlled, non-radiating body. (ARS 956-59).

Outline of the Mechanics of the Power and Launching Phase for Missiles and Satellites, Carl A. Traenkle, Aeronautical Research Laboratory, Wright Air Development Center, Wright-Patterson AFB, O.

The author demonstrates how optimization problems of missile trajectories and satellite orbits can be solved very quickly by the method of "Reference Trajectory," followed up, if required, by the "Perturbation Method," thus refining the results to any wanted degree of accuracy. (ARS 958-57).

Planetary Perturbations of Interplanetary Orbits, James E. Michaels and Evelyn A. Strawbridge, Missile and Space Vehicle Dept., General Electric Co., Philadelphia.

The authors study the perturbation effects of the planets on interplanetary ballistic trajectories. The analysis results in an equation which integrates the instantaneous accelerations of a perturbing planet on a space vehicle over a predetermined ballistic flight path, giving the total deviation from that flight path. (ARS 957-59).

Researches in Interplanetary Transfer, John V. Breakwell, Rollin W. Gillespie and Stanley Ross, Lockheed Missiles and Space Div., Sunnyvale, Calif.

The paper explains a method by which interplanetary trajectories may be calculated extremely rapidly and to a degree of accuracy suitable for design studies. By splitting the three-center problem associated with interorbital ballistic transfer into three one-center segments which overlap somewhat at their junctions, solutions may readily be found by machine iteration. The extreme speed of the method enables wholesale amounts of worthwhile numerical results to be obtained. (ARS 954-59).

Power Systems

A Method of Predicting Missile Power Unit Performance Through the Use of Rocket Parameter, Paul C. Juhasz, Boeing Airplane Co., Seattle.

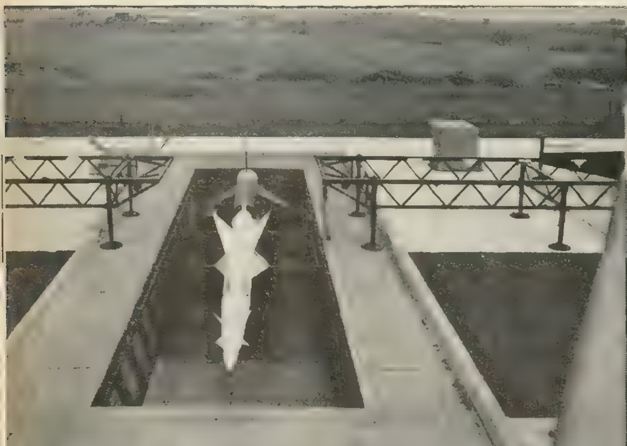
Presents arguments and supporting data for use of specific impulse as a suitable parameter for measuring performance of missile propellant-type secondary power units. (ARS 1036-59).

Approaches to the Ultimate in Conversion of Solar Heat-to-Electricity, Thomas Timar, Boeing Airplane Co., Seattle.

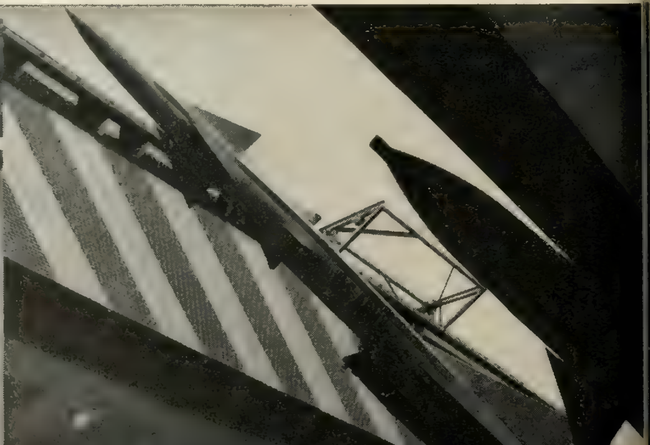
Discusses potential of thermal devices in converting solar energy to electric power. Shows what could be accomplished in weight reduction by converted effort and predicts that thermal devices may yet prove better than solar cells. (ARS 1038-59).

About the earthly side of the Nike Ajax.

The U. S. Army's Nike Ajax is a strange but potent bird. Graceful, tough, packed with delicate instruments. He will fly only once in his lifetime—only in the event of an enemy attack. To launch him with split-second timing and accuracy, the Army puts most of its manpower and most of its materials into ground equipment. And virtually all the material required other than electronic equipment can be purchased from one firm—United States Steel. Whether you're talking about carbon steel, high-strength low-alloy, or ultra high-strength alloy steels, Stainless Steel, steel fence,



The Nike Ajax spends his days in a concrete and steel nest like this one. ICBM's will also live this way, but in nests that will take *thousands* of tons of concrete and steel. U.S. Steel specialists work continually with designers and construction engineers to find ways to use steel to its full advantage on such projects to build stronger with less materials . . . to build them faster.



It takes miles of wire and cable to rig a Nike nest. It will take *hundreds* of miles when bigger birds are put to roost. The Army uses many types of steel and steel products in a Nike nest. U.S. Steel conducts research and knows how to cut costs for any steel product used in ground support equipment.

electrical cable, cement or wire rope, United States Steel maintains the technical services to provide the proper assistance to cope with any problem on materials for ground equipment. When a ground support program goes to the drawing board, consult with

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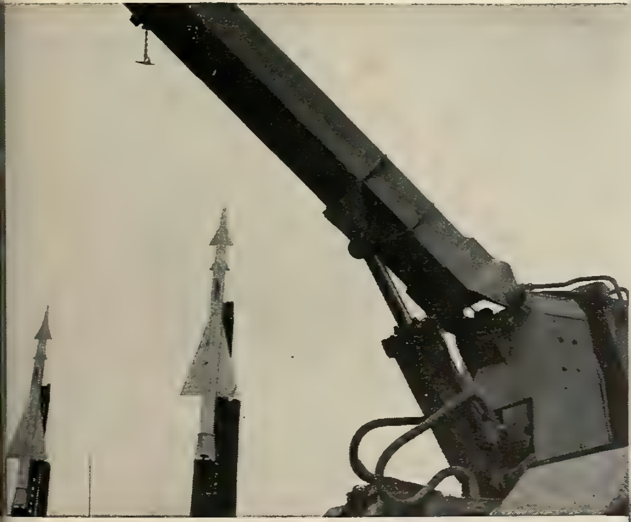
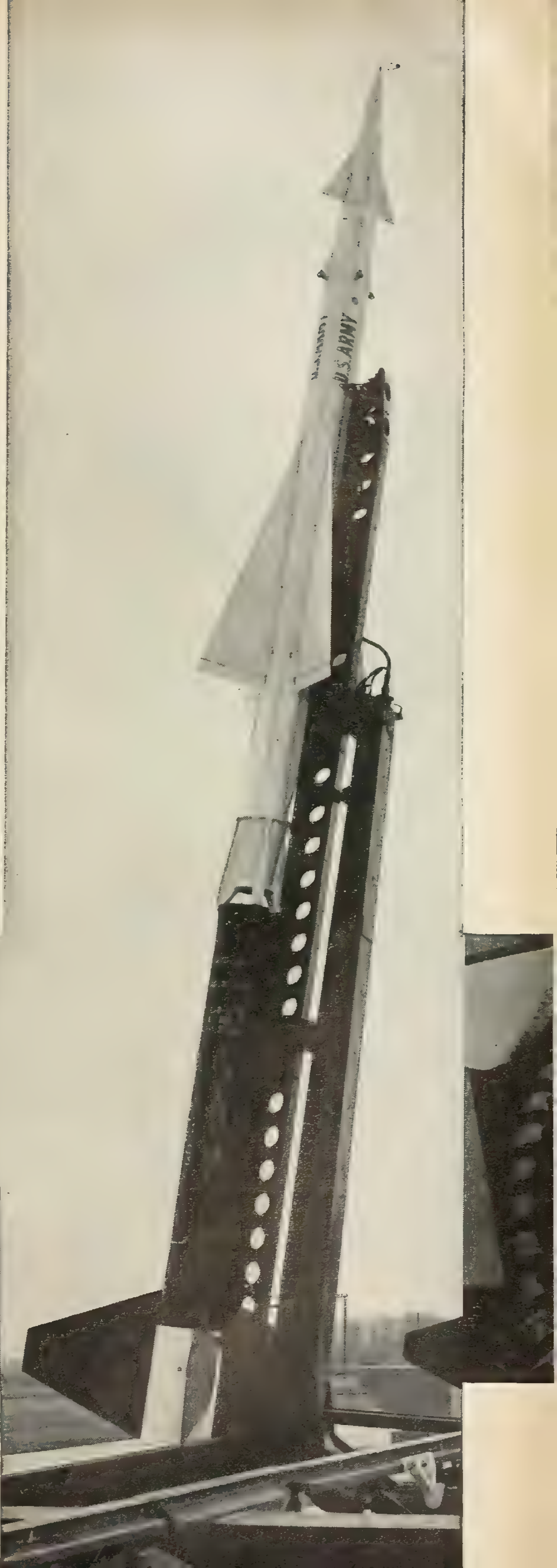


How light can you make a steel boom for any missile system without sacrificing strength? The proper selection of USS High-Strength Steels or Constructional Alloy Steels has cut the weight of similar equipment as much as ⅓—and *increased* the strength and service life.



New Thermal Relay Is Produced for Missile Use

A Type PT Thermal Time Delay produced by **GV Controls Inc.** is said to be a new design developed to provide greater shock and vibration resistance and higher precision than has been available before.

This relay may be operated under vibration of 20 g up to 200 cps and under shock of 50 g for 11 ms. There is no resonance below 2000 cps and extended exposure to these conditions causes no damage or change in characteristics.

Operating time delays of 3 to 60 seconds are available. Time delay is factory set within a tolerance of ±5%. Effects of ambient temperature have been greatly reduced and are held to ±5% over the range of –65°C to –125°C. Heater voltages range from 2 to 115 volts for delays of 3 to 12 seconds and from 2 to 230 volts for the longer delays.

Relays are hermetically sealed in a rectangular case 1 3/16" x 2 1/4" x ¾" high. Leads project thru the bottom of the case and are located on 0.2" grid spacing for convenience in use with printed circuits. Weight is 2 to ¼ oz.

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Coating Temporarily Protects Polished Surfaces

Temporary protection of polished surfaces—metal, glass and many plastics—is provided by a new, scratch-resistant coating, Zincilate WST-100, that can be easily removed with a simple warm water rinse. The product is offered by **Industrial Metals Protectives Inc.**

The coating is non-flammable, will withstand forming and bending, and offers complete resistance to petroleum solvents. It is a non-reactive, inorganic type of coating that air-dries to full hardness in 30 minutes. Drying time can be reduced with warm air circulation or infrared baking.

Zincilate WST-100 requires no mixing, may be applied by spray, dip, roller coat, flow coat or pressure curtain methods. No special surface preparation other than a normal solvent wipe is needed. Coverage will average 1000 sq. ft. per gallon, at .001" thickness. Complete information may be obtained from Industrial Metal Protectives, Inc., 401 Homestead Avenue, Dayton 8, Ohio.

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Machine Separates H_2, N_2 from Ammonia

NEW YORK—A compact machine capable of producing high-purity hydrogen and nitrogen gases from ammonia is being marketed jointly by **North American Phillips** of New York and **Hamler-Lewis, Limited,** of Chicago.

The device, known as the Norelco Ammonia-Gas Separator, employs a super-cold refrigerator and should eliminate problems often encountered in the delivery of hydrogen from outside sources, problems such as municipal transport restrictions.

Hamler-Lewis will install the separators on direct purchase or lease contracts, service the equipment and provide high-purity, metal-treating-grade ammonia delivery.

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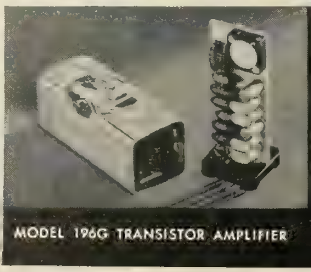
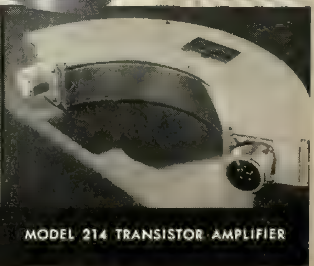

MODEL 196G TRANSISTOR AMPLIFIER


MODEL 214 TRANSISTOR AMPLIFIER

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Relay Satellite System Under Development

An experimental communications relay-satellite system is being developed by **Bell Telephone Laboratories,** which has begun building the first prototype station here.

Primary objective in the program is to determine whether such a system could transmit and receive transcontinental broadband (900-channel equivalent) signals.

The experimental program will also provide several by-products: microwave radio signals will be analyzed to learn more about transmission effects, and the reflection characteristics of an orbiting satellite will be studied from the data obtained.

Two types of antennas will be employed: a paraboloidal reflector for transmitting, and a horn reflector for receiving. Almost perfectly unidirectional, the Bell Lab-developed horn antenna picks up less than one millionth as much as from other directions. It reduces ground radiation degradation to a minimum, according to Bell.

A highly sensitive receiver will employ either a pair of parametric amplifiers or masers for noise reduction.

The satellite experiments are expected to be preceded by test transmissions using lunar reflection. The test path—2300 miles long—will be between **Jet Propulsion Laboratory**'s tracking station at Goldstone, Calif., and Bell's new Holmdel site.

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Servo Valve Has Only Two Moving Parts

Kearfott Co., Inc. a subsidiary of **General Precision Equipment Corp.,** has introduced a unity-coupled shear orifice electrohydraulic servo valve capable of optimum performance in severe environments.

The valve consists of only two moving parts—a spool and a sliding fork integral with a torque motor's armature. Of titanium construction, this valve has large, full-opening "shear seal" orifices which virtually eliminate silting problems, while high shear forces easily clear the valve of contaminants. Essentially a two-stage four-way control valve, Model 6103's first stage consists of an electrical torque motor and a "shear-seal" orifice hydraulic amplifier; its second, or control stage consists of a precisely matched spool and sleeve arrangement.

Hydromechanical unity feedback relates spool position to torque motor armature position and also nulls out the effects of orifice variations produced by fluctuations in supply pressure and temperature. With hydromechanical positional feedback, flow force reactions are substantially reduced and hydraulic centering of the pilot position is accomplished without the spring hysteresis and null shift commonly encountered in valves using the force feedback principle.

Springs and mechanical null adjustments have been eliminated entirely, and final null adjustments are made electrically by a balancing control at the amplifier output stage. The torque motor's high power and long stroke contribute to valve stability, minimizing the effects of temperature shifts, vibration, and mechanical stresses.

High differential pressure on the spool, together with spool and sleeve hardness, combine to provide effective dirt shearing action and freedom from friction in the second stage. Susceptibility to magnetic contaminants has been minimized, and although fluid is allowed in the motor cavity to cool the coil at high ambient temperatures, the cavity is isolated from load flow by spool lands and baffles.

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west coast industry . . .

BY FRANK G. McGUIRE

A Palo Alto research and development company with 26 employes and two boards of directors has taken an interesting approach to formation of a successful R&D effort. **Vidya, Inc.,** a partly-owned subsidiary of **Itek Corp.,** recently announced the composition of its scientific board of directors, which will provide counsel to technical and administrative top management in high-level decisions. Vidya is a relatively new firm specializing in orbital mechanics and control, re-entry, plasma physics, space electronics, and other sophisticated areas of space flight.

The scientific board of directors includes Luis W. Alvarez, physics; Dr. Nicholas J. Hoff, structures; Dr. Samuel A. Schaaf, aerodynamics; Dr. Joseph M. Pettit, electronics; and Dr. Kenneth Street, Jr., chemistry. Members of the business board of directors, some of whom would apparently qualify for the scientific board as well, include chairman J. H. Carter, a vice president of Itek Corp. and formerly manager of the *WS117L* program (*Agena, Discoverer, Midas,* etc.) at **Lockheed,** and company president Wallace F. Davis.

Originally formed by a group of senior scientists, many of them from the Ames Laboratory of NASA, Vidya was purchased by Itek this year, and reportedly has unlimited financial backing from the parent firm. The present group of 26 scientists and supporting personnel is expected to increase to several hundred within two years, and the company is now forming an aerospace division.

Convair's battle for a new warehouse site . . .

has reached the stage of circulating petitions, newspaper editorials, "unidentified interests" and indignant declarations. Cause of the uproar is the rezoning of a 24-acre plot of land adjacent to **Convair-Astronautics** from residential to industrial use, thus allowing Convair to build on it. The rezoning, approved by the city council and city planning commission, will take effect December 4, unless 9273 protesting signatures are presented on a petition by the previous day. The petition, with unknown backers, is being circulated by a professional petition circulator in hopes of blocking construction of the $4-million warehouse needed for the *Atlas* program. Many believe that the "unidentified interests" vigorously opposing the rezoning are an unsuccessful group of bidders for the warehouse site. Convair would be forced to buy other land if its present plans are blocked, and owners of nearby available land are suspected of backing the petition and other agitation.

Number of workers in aircraft/missiles . . .

in Southern California has doubled in the past nine years, despite recent general trends toward fewer production workers. It will be interesting to note the trend over the next nine years. Although no breakdown is available for aircraft/missile wages, the average weekly wage of employes in all manufacturing in Southern California was $65.58 in 1950 and $102.82 in September, 1959, both assuming a 40-hour week.

Arnoux Corp.'s fourth acquisition in four months . . .

indicates a rapidly expanding complex of electronic capability for the firm. Through its Automation Electronics division, **Arnoux** has acquired **Perfex Connector Corp.** for an undisclosed amount. Perfex recently moved into a brand new plant in Monrovia, where it manufactures both special and standard types of connectors. In August, Arnoux announced acquisition of **Instrol, Inc.,** of Santa Barbara, and **Automation Electronics Inc.** In October, **Astra Technical Instrument Corp.** joined the family as a producer of temperature transducers. More growth is reported to be in the making.

The Infrared Information Symposium . . .

held in Pasadena recently brought out some interesting figures in IR's future. It was predicted that this field will be in the $500 million category as a market by 1961, and will hit $5 billion by 1965. But nobody will know about it unless IRIS security loosens a bit. Of the 850 attendees at the meeting, 65 were security officers from various agencies.

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☐ Opportunity for Advancement.

Spacecraft and advanced missile projects—including Minuteman solid-propellant ICBM—are expanding at Boeing, creating an increasing demand for electronic-electrical engineers capable of moving up to positions of greater responsibility and income. To help engineers get ahead faster, Boeing maintains a company-paid graduate study program, and conducts regular personal merit reviews to assure you a continuing opportunity for individual recognition and advancement. Boeing also carries out other company programs designed especially to develop personnel for added responsibilities.

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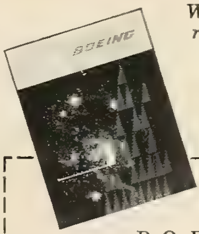

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people

Thomas E. Gootée has left Government service to accept an executive position with Page Communications Engineers, a subsidiary of Northrop Corp., located in Washington, D.C.

GOOTÉE

Gootée will be Assistant Director of Maintenance and Operations for the firm, which performs government industrial global communications systems engineering, particularly in the fields of tropospheric, ionospheric scatter communications.

Prior to military and civilian government service, he was a field engineer with the National Broadcasting Co. in Chicago and New York.

J. C. Pitchford has been named vice president in charge of engineering at Benson-Lehner Corp. He will be responsible for the management and direction of the firm's expanding engineering department, with particular emphasis on implementation of a program for development of new products.

Jack Bair has been named Chief Mechanical Design Engineer for North Atlantic Industries, Inc.

BAIR

In his new assignment, Bair will direct design work associated with product diversification and the application of products to modular instrumentation systems for aircraft, missiles and ground check-out requirements.

Prior to joining the firm he was project mechanical engineer at Reeves Instrument Corp. where he was associated with the design of inertial platforms for the bomb scoring system used in development of toss bombing methods. He also worked extensively on miniaturized transistor amplifiers designed to extreme environmental and performance specifications.

Dr. Robert A. Fuchs has joined Electro-Optical Systems, Inc., as a principal scientist and head of the systems analysis group of the Space Defense Systems Division.

Prior to joining EOS, Fuchs was a member of the technical staff of Space Technology Laboratories where he was active in systems analysis work.

Maxwell H. Harts has been appointed chief engineer for Alpha Wire Corp. where he will be responsible for the company's research and development activities, maintain quality control and supervise the manufacture of custom cables.

Brian M. Gallagher, former design engineer with the Electro-Motive Division of General Motors has been named design engineer for Solar Aircraft Co. **Ben C. Axley, Jr.,** previously with Lockheed Missiles and Space Division, has been named chief of avionics in the research and development engineering division of Solar.

David E. Shonerd has been appointed vice president, engineering for Rocket Power, Inc., a division of The Gabriel Co.

SHONERD

Prior to joining the firm, Shonerd was assistant program director for the *Minuteman* weapons system at Space Technology laboratories. Before that, he was president of Era Engineering, Inc., developers of missile instrumentation. At Rocket Power, he will be responsible for all engineering operations relating to solid propellant rockets, high-altitude sounding systems, infrared energy sources, gas generation cartridges and space applications of solid propellants.

DeHavilland Propellers Ltd., has appointed **G. C. I. Gardiner** as Chief Executive of Ballistic Missile Engineering. He relinquishes his position as Chief Engineer but remains Technical Director of the company.

Three chief engineers have been appointed: **T. W. Air** becomes chief engineer of Ballistic Missiles; **G. H. F. Brown** chief engineer Propellers, Aircraft and Industrial Equipment; **Dr. G. H. Hough,** chief engineer Air-to-Air Guided Weapons and **C. C. Williams** has been named general manager.

Dr. Joseph Hull, formerly chief scientist, has been promoted to Director of the Research Laboratory of Litton Industries Electron Tube Division.

John F. Biehle has been appointed to the newly-created position of Technical Director of the Beryllium Components Division of Astrometals Corp.

BIEHLE

Biehle will be responsible for direction and coordination of research and development projects on beryllium, as well as provide technical liaison with industry and government agencies.

He was previously associated with Misco Precision Casting Co., Allegheny Ludlum Steel Corp. and Republic Steel Corp.

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VERSATILE AIR CONTROL APPLICATIONS The revolutionary 412L can be used to defend a single airfield, or, by linking control sites together, it could be used in a limited action to provide air control for an area the size of Alaska. Similarly, by linking the capabilities of countries together, a system could be provided for the air control of an entire continent. Designed for both fixed and mobile applications, the 412L will be used primarily outside the U. S. since the SAGE system is used for the defense of this country.

HMED IS ALSO DESIGNING THE "HEART" OF THE SYSTEM In addition to its prime mission of providing systems management, HMED will design, develop and produce the data processing and display subsystem which is the "heart" of the 412L. Capable of rapidly and automatically detecting and tracking air targets, the subsystem operates without human assistance, except under unusual circumstances.

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- Underwater Detection Systems
- Missile Guidance
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contracts

NAVY

$809,592—**Raytheon Co., Microwave and Power Tube Div.**, Waltham, Mass., for electron tubes.

NASA

$178,000—**University of Cincinnati**, for research in celestial mechanics; the study of movements of celestial bodies in relation to gravity.

MISCELLANEOUS

$400,000—**Flite-Tronics, Inc.**, Burbank, Calif., for the design and manufacture of laboratory test equipment. Subcontract from **Hughes Aircraft Corp., Products Division.**

$200,000—**Yardney Electric Corp.**, N.Y., for the manufacture of compact, high-rate silver-zinc missile batteries. Subcontract from **Convair and Convair Astronautics Div. of General Dynamics Corp.**

$200,000—**Temco Aircraft Corp.**, Dallas, for machining of components of a classified electronic countermeasures system. Subcontract from **Sperry Gyroscope Co.**

AIR FORCE

$101,000,000—**General Electric Co.**, for continued development of advanced re-entry vehicles for *Thor* and *Atlas* missiles.

$2,210,594—**Sperry Rand Corp.**, for components of radar set AN/APN-59 and data.

$2,000,000—**Collins Radio Co.**, Dallas, for engineering, manufacture and installation of a microwave communication system for Fairchild AFB.

$323,175—**Douglas Aircraft Co., Inc.**, Santa Monica, for 465 modification kits for the MD-1 rocket motor applicable to the *MB-1* rocket.

$61,000—**Corning Electronic Components**, Bradford, Pa., for feasibility study of multiple-tapped delay lines.

ARMY

Consolidated Diesel Electric Corp., Stamford, Conn., has received follow-on orders for hydraulic services consoles to be used in connection with the *Lacrosse* surface-to-surface missile. Amount not disclosed.

Kearfott Co., Inc., Little Falls, N.J., a subsidiary of **General Precision Equipment Corp.**, has received an award to design, develop and build hydraulic control systems for the *Pershing* missile. Amount not disclosed.

Waste King Corp., Technical Products Div., Los Angeles, for research in the development of special lubricating systems for improved-performance gear drives.

$8,617,624—**Aeronutronics Div., Ford Motor Co.**, Newport Beach, Calif., for *Shillelagh* missiles, a new light-weight surface-to-surface-weapon used for close-in support of troops.

$7,500,000—**Radioplane Div. Northrop Corp.**, Van Nuys, Calif., for production of 400 RP-76 rocket-powered target missiles; broad flight service program to fly target missions for Army Air Defense practice teams firing *Nike-Ajax* and *Hercules* missiles. The ground support, control, and checkout equipment for the target missile system is also included.

$4,321,658—**Henry C. Beck Co.**, Palm Beach, Fla., for construction of a complete launch complex (excluding blockhouse and serve structure) including above grade launch pedestal, subpad rooms, fuel and liquid oxygen facilities, high-pressure gas facilities and other supporting facilities for the *Saturn* rocket site at Cape Canaveral Missile Test Annex, Patrick AFB.

$1,705,379—**Western Electric Co.**, for engineering and technical services in the *Nike* field support program.

$950,000—**Raytheon Co.**, Waltham, Mass., for engineering services for the *Hawk* missile.

$830,580—**Chrysler Corp.**, Detroit, for additional services on *Redstone* missile systems.

$542,885—**Sperry Rand Corp.**, Salt Lake City, for design, engineering and fabrication of transistorized amplifier units.

$200,000—**Electrodynamics Corp.'s Datalab Div.**, Pasadena, Calif., for magnetic-tape recorder/reproducers for use in connection with Project *Courier*.

$152,175—**Sylvania Electric Products, Inc.**, Waltham, Mass., for engineering study of satellite tracking system.

$119,000—**Sperry Rand Corp.**, Salt Lake City, for furnishing and delivering repair parts for missile systems. (Two contracts.)

$50,158—**Monsanto Chemical Co.**, Everett, Mass., for electrochemical research of fuel cell technology.

$26,649—**Curtiss-Wright Corp.**, Princeton, N.J., for preliminary design study and design and construction of a laboratory-scale thermoelectric generator for application beyond the earth's atmosphere.

BIDS

Procurement Branch, Aberdeen Proving Ground, Md.—Camera, thermal image: in a/w spec entitled Spec for Camera, Thermal Image—1 each—IFB ORD 18-001-60-64. Bid opening 11 December, 1959.

Purchasing and Contracting Div., White Sands Missile Range, N.M., ORDBS-P&C—Research metallograph unit—1 each—required delivery 120 days—IFB ORD 29-040-60-117—Bid opening 14 December, '59. Bid sets available through 7 December '59. Recorder, oscillographic, galvanometer type, with one quick look magazine. Required delivery 60 days FOB White Sands Missile Range, N.M. Bid sets available through 27 November or until exhausted. 1 each—IFB ORD 29-040-60-92—Bid opening 7 December '59.

Ogden Air Materiel Area, Hill Air Force Base, Utah. Attn: Directorate of Procurement and Production.—5 inch rocket target kit, type TDU-14/B—2498 each—IFB 42-600-60-90B—Bid opening 21 December '59. When replying mark OOPPPT.

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Please contact specifying salary requirements:
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ORDNANCE DEPARTMENT
Of the Defense Electronics Div.

GENERAL ELECTRIC
100 Plastics Ave., Pittsfield, Mass.

The DOD Tells Industry

In an address before the American Management Association in New York recently, James P. Falvey laid down some cogent guide lines for industry in dealing with the military. Since Mr. Falvey is Deputy Assistant Secretary of Defense for Supply & Logistics, and since his points undoubtedly had the sanction of Secretary McElroy, industry might well give his words some close attention.

The Department of Defense, he said, expects American business to discard any feeling of complacency with its own progress and alleged invincibility. Maybe we are tops in automobiles and television sets, but:

> **"The cycle of industrial history has made a 180-degree turn. Survival does not depend primarily on mass production. We do not need any massive number of intercontinental ballistic missiles. And these weapons, in large measure, represent craftsmanship rather than mass-production capability. We are now in a period when scientific genius, supported by meticulous shop craftsmanship, has been phenomenally successful in building weapons of cataclysmic fire power."**

The major points he made to his management audience were these:

Survival depends on what we have now. Weapons delivered to the military must be of the highest possible quality and reliability—the nearest thing to perfection.

The cost of weapons must be reduced. Produce the simplest designs that will do the job. Make them reliable—but not gold-plated.

Use standard components and stop redesigning out of self-interest.

Industry has an obligation to take the initiative in eliminating superfluous requirements and to achieve standardization. Advise the contracting agency of wasteful and superfluous contractual requirements of any kind.

Months of time and a great deal of money are frequently wasted because technical proposals for negotiated contracts are delayed or incomplete. To be wary about disclosing full company data is a mistake. Procedures guarantee protection.

Time and money will also be lost if original pricing proposals are not realistic. Cost data must be up-to-date, complete and accurate.

As the military increases the concentration of military funds in costly individual projects, both the Department of Defense and probably Congress will insist on wider use of subcontracting. The Department of Defense small business subcontracting program, which has been undertaken on a voluntary basis in the past by several hundred military prime contractors, will very soon be mandatory on all recipients of military prime contracts of $1 million or more which offer subcontracting possibilities.

Industry must have the ability to discard old ideas, old weapons, obsolete equipment and unneeded facilities in favor of new products and production methods. The tendency to seek continued production of outmoded equipment for any reason, including the economic interest of a particular locality, is an unjustified industrial myopia.

These points, perhaps, are not radically new, but they are put with a succinct bluntness that is unusual outside the small, classified briefings that are sometimes held in the Pentagon. Couple these points with the stringency of the proposed 1960-61 budget. Calculate the competition for military projects and weapon systems both proposed and under way.

The conclusion seems apparent: future military contracts, from prime to the smallest component, are going to fall to the companies with known or demonstrable capabilities, recognized techniques—and sharp pencils.

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NEW PRODUCT BRIEFS

AUGE. Astra Corporation of Hatboro, ., has developed a gauge for use in gh pressure application, 1000 to 100,- 0 p.s.i.g. This six-inch diameter gauge available in twelve ranges from 1000 100,000 p.s.i.g. Its element is a spe- al drawn and formed 316 stainless steel ıltiturn helical Bourdon tube which ves longer life, and greater accuracy, d resists fatigue. It has mechanically aled ends, to permit cleaning. This ecial element is available in all ranges cluding 100,000 p.s.i.g. A new full rup- re Teflon diaphragm back provides aximum safety. Other safety features clude a high tensile safety plate be- een the element and the viewer and laminated safety dial glass. Of special erest to the use is the fact that the al is designed for maximum readability divisions are spread over 300 degrees the dial for all ranges. The ASTRA- UAGE is designed to Class AA stand- ds (ASA B.40.1-1939)—1/4 of 1% ac- racy. The movement is of stainless eel throughout and special linkages re- ice shock and vibration. In order to tain maximum accuracy and to pro- de for auxiliary equipment, the move- ent and element are designed for aximum power in each range.

rcle No. 295 on Subscriber Service Card.

ANIPULATOR. Positioning and clamp- g work for welding, moving material and out of air locks, and many ordi- irily difficult tasks in vacuum are made ısy by the RYE M-1 manipulator. andling can be done over a wide essure range from positive pres- res to better than 10^{-6}mm Hg, through e of double-pumped vacuum seals. Full otion through a 90° cone is possible th the easy 90° action ball joint. The foot stainless steel shaft can be moved and out of the chamber and rotated. ısitive acting parallel jaws are con- olled by a pistol grip handle. The andard manipulator is furnished with a achined attachment plate with an "O" ng for positive seal, or is available ounted on blank-off plates or other nfigurations. Model RYE M-1 HT is stainless steel beyond the handle and igger assembly and is especially use- l for high temperature applications.

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RESSURE PUMP. A medium-pressure odel is now available in the Turbocraft family of petrochemical and cryogenic transfer pumps. The medium-pressure Series 2000 is intended for liquefied gas trailer and similar applications where compactness and lightness is essential. The pump is also useful for evaluating small, low-thrust rocket engines, replacing complex pressurization systems, and units have been supplied for liquid hydrogen and fluorine service. The pump's extreme flexibility allows it to be used either as a fuel pump or as an oxidizer pump in high-speed continuous or intermittent operation without cavitation. It can be removed from any system without affecting suction or discharge piping. Mounting can be vertical or horizontal.

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CONVERTER. Data conversion from four binary inputs to a tape recording in the IBM 704 format is possible with an all-transistor data converter now being manufactured by the Electronic Engineering Company of California. The Data Converter will convert a 27-bit time code, one 20-bit data signal, and two-17-bit data signals into an IBM 704 magnetic tape. The unit will also supply signal outputs to seven central locations also in the IBM 704 coding but without gaps between the blocks. The sampling rate of the input data may be selected at 10, 20, 40, 80 or 100 pps. The Data Converter was designed for the multiplexing and the recording of range, azimuth, and elevation data from digital radar outputs together with a timing signal.

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WHEEL DRESSER. A grinding wheel dresser, Model #10, is designed to fill a long existing need in Industry for a heavy duty—low cost wheel dresser, has been produced by the L. Newman Co. 6" long with a 3/4" diameter shank. Made of high tensile strength cast aluminum alloy. Arbor equipment with sealed ball bearings. Specially developed cutters and abrasive wheels are interchangeable. The built-in tangential angle of the cutters (or wheels) eliminates the need for a breaking device and assures sharp, cool grinding, while eliminating burn checks and flying dead grain. In factory tests this tangential angled dresser provided 2/3 more grinding per trim. Model #10 will fit standard peterson cylinder head and lempco grinders.

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MISSILE LITERATURE

STEEL. A booklet on a high strength steel for use in missiles and rockets is now being distributed by Allegheny Ludlum Steel Corporation. The booklet, entitled "Potomac A High Strength Steel," is 24-pages long, and contains numerous graphs and charts on this chromium-molybdenum-x vanadium hot work steel. The steel, known as type H-11, is noted for its high strength up to 1000 degrees F, and is used in landing gears, solid propellant rocket cases, structural sections of aircraft and missiles, and many other applications.

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MISSILE ELECTRONICS. General Precision Equipment Corp., has issued a four-page text booklet describing achievements in navigation-guidance-control, data handling, detection, tracking and fire control and simulation and test equipment. It identifies principal components and systems programs underway at GPL, Kearfott, Librascope and Lind subsidiaries.

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BUTTERFLY VALVES. A new four-page condensed bulletin describing the complete line of Continental butterfly valves is now being distributed. Eight butterfly valve designs are presented in tabular form, which makes comparison and selection easy. Valve sizes range from 1" to 108", with pressure drops up to 1200 psi and temperatures up to 2000°F.

Circle No. 202 on Subscriber Service Card.

ICE CALIBRATOR. An instrument which calibrates the thickness of ice on liquid oxygen tank exteriors during static missile test firings has been developed by Task Corporation, Anaheim, California. Task engineers state the probe, which bolts directly to a sheet metal mounting pad, can accurately record ice depth within ±.010 of an inch. Containing a 15-24 volt D.C. operated rotary solenoid, a continuous AC signal is transmitted by a 10,000 ohm potentiometer within the unit. Cycling every 5 or 10 seconds, the signal is broken by one of two microswitches to enable an immediate reading on the test equipment while the second microswitch provides a DC signal to close a relay and deliver the arm of the probe to the return position. The device is 4" by 8" and the arm measures 12" in length. Entire unit is said to feature internal hydraulic damping and is sealed from external environment. Mounting provision can be modified to meet customer specifications.

Circle No. 203 on Subscriber Service Card.

LEAK VALVE. Scientific Engineering Laboratories, Inc. has announced a new Palladium Leak Valve for control of hydrogen and deuterium gas flows. This valve consists of a 3½-inch diameter chamber, 4½ inches high, with a palladium thimble. The top flange is 5 inches in diameter and ¾-inch thick. Input and output connectors are female ⅛-inch diameter pipe fittings. Input can be pressurized up to 15 psi gauge. The valve is heated by an external 117-volt ac heater designed to be powered by a Type 10 Powerstat.

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MAGNETIC TAPE. A four-page illu trated bulletin describing CEC Mag netic Tape for digital and analog re cording is available from the DataTap Division of Consolidated Electrodynam ics Corporation. Information include performance qualities of the new tape production techniques, and specifica tions.

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ZENER DIODES. A 130 page manua covering basic theory, design charac teristics and applications for zener (vol age limiting) diodes has just been an nounced by Motorola's Semiconducto Products Division. This new handboo the first of its kind, is intended to serv as a guide in the use of this versatil and relatively new component. Chapte headings include: Characteristics of Sil con Zener Diodes, Design Consideration Regulated Power Supplies, Surge Pro tection, A.C. and D.C. Amplifiers, Tem perature Compensation and Impedanc Cancellation, New Approaches in Zene Diode Applications, and Specification and Testing Methods.

Circle No. 206 on Subscriber Service Car

PRECISION WIRE. Technical Data o precision wire wound and compositio variable resistors is being offered in th new 24-page engineering catalog jus published by Reon Resistor Corp. Thi collection of valuable engineering in formation is divided into two sections one devoted to the precision wire wound resistors and the other to the variabl resistors. In the precision wire wound sections such subjects are discussed as characteristics of resistance wire; temper ature coefficient interpretation; "E temperature coefficient; special tempera ture coefficients; termination of resis tance wire; MIL-R-93B and MIL-R-944 nomenclature. The subject matter of th REON composition variable resistor sec tion includes: MIL-R-94B nomenclature the Reon part numbering system; in terchangeability and a complete chart summary of test results on Reon variabl resistors.

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ELECTRONIC COMPONENTS. Bulleti GEZ-2910, 12 pages, describes Genera Electric's complete line of transformers reactors, power supplies, modulators and other components for high voltage ap plications in the electronics industry Publication includes pictures and de tailed information on the features, char acteristics and operation of the com pany's full line of products including "packaged" equipments such as pulse and filament transformers, rectifier and filament transformers, and power sup plies, including rectifier transformer, fila ment transformer, filter and charging re actors.

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RESISTORS. Chicago Telephone Suppl Corp. has released a data sheet giving dimensional drawings and complete tech nical data on its new line of ¾" dia meter miniature preset wirewound ½ to 5000 ohms resistance range variabl resistors.

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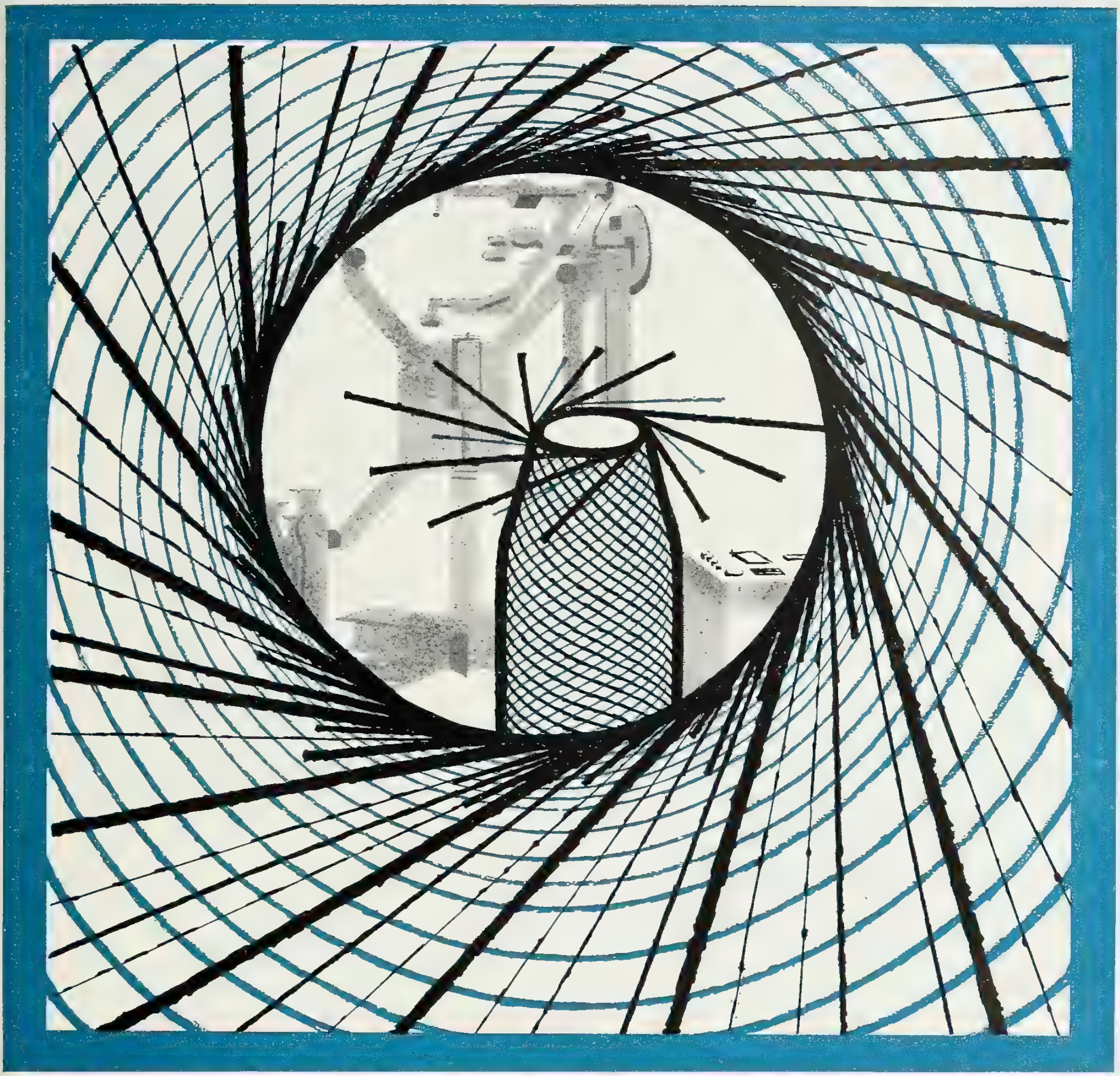

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Get more information on how SBP can serve you. Write or call: The Brunswick-Balke-Collender Company, Defense Products Division Sales Manager, 1700 Messler Street, Muskegon, Michigan—today!

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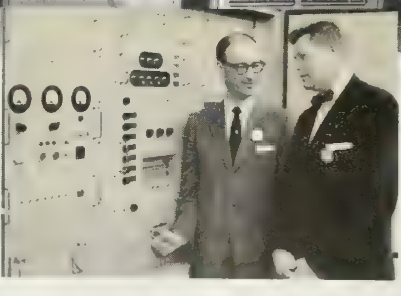
Digital read-out sub-system of a large, automatic, transistor production checkout system.



Sub-system for the ground support equipment on the B-58 **Hustler** program. Measures AC and DC single-ended voltages and ratios, and AC and DC differential voltages and transients. Chosen for its excellent operating characteristics under adverse environments.

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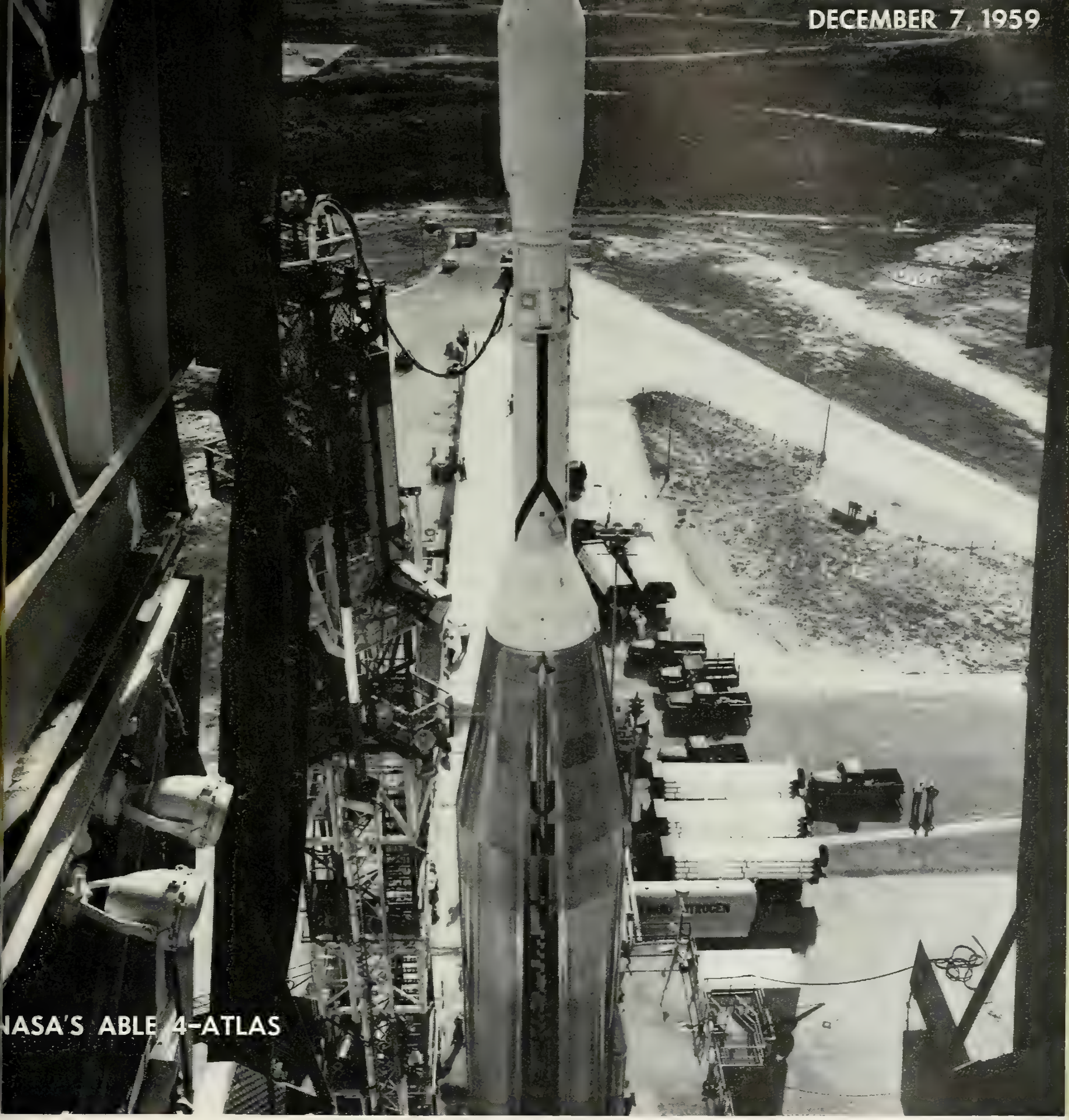
DECEMBER 7, 1959



NASA'S ABLE 4-ATLAS

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

How Soviet Engines Got That Way .17
Energy Conversion Gains Impetus .22
A Survey of Hustling San Diego . . .25

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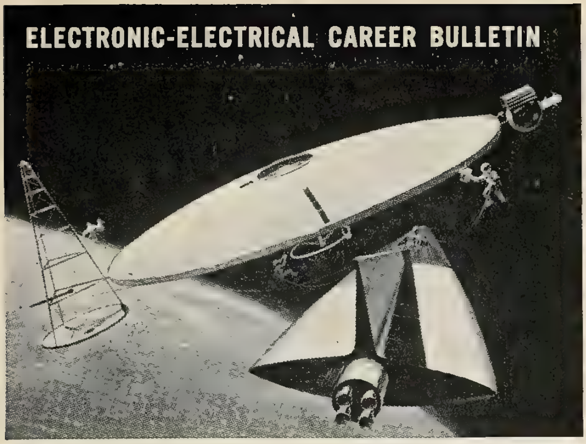
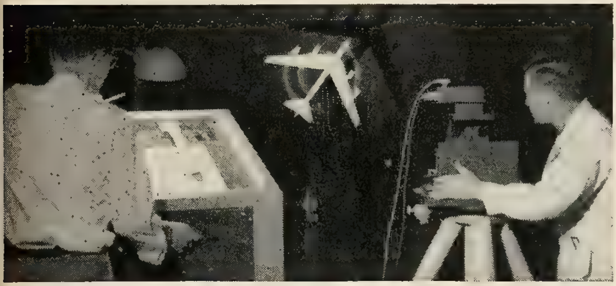
ELECTRONIC-ELECTRICAL CAREER BULLETIN



MARS VEHICLE. Drawing, based on Boeing study, of space vehicle designed for launching from orbiting platform for reconnaissance flight to Mars and return. Lunar, orbital and interplanetary system studies, and expanding programs such as the advanced Minuteman solid-propellant ICBM, are typical of challenging, long-range assignments Boeing offers electronic-electrical engineers.



DARK TUNNEL. View in 100-foot dark tunnel, part of extensive Boeing infrared research and development facilities. Boeing investigations include use of infrared, visible and ultra-violet techniques for use in communication, navigation, detection and guidance at altitudes above tropopause. IR systems, inertial navigation, electrical power systems for satellites, shockwave radiation and refraction and irdome heating are other areas of assignments open at Boeing.

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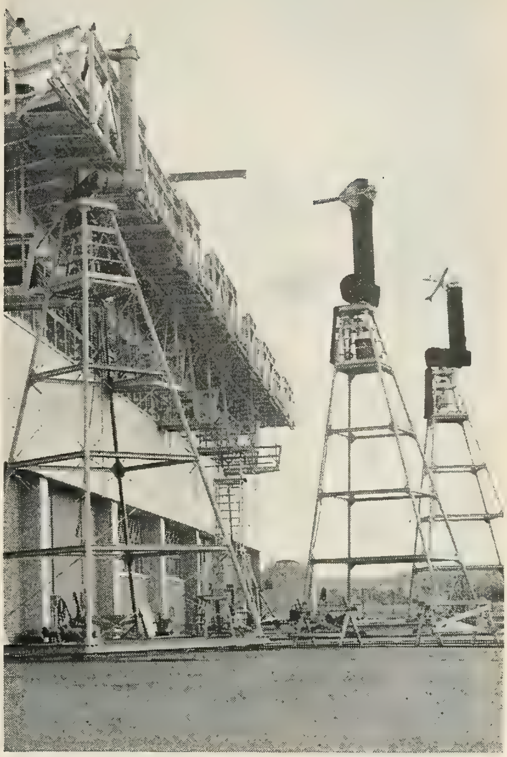

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missiles and rockets

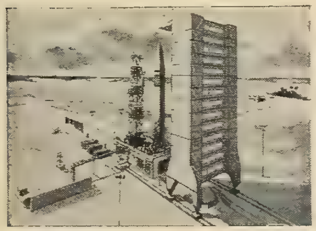
MAGAZINE OF WORLD ASTRONAUTICS

30,900 copies of this issue printed

COVER: Ill-fated *Atlas-Able* vehicle is shown on launching pad at Cape Canaveral prior to unsuccessful moon shot attempt on Nov. 26. An assessment of where the failure leaves U.S. space program starts on p. 30.

MASSIVE solar converter of Hoffman Electronics is indicative of growing emphasis on energy conversion for both military and industrial applications. See story on p. 22.

ARTIST'S conception of the 120″ diameter Spin Forge machine which Hufford Division of the Siegler Corp. expects to have in operation by next July. It will be world's largest. See p. 27.



TALLER THAN a 16-story building will be this steel gantry tower (shown in artist's drawing) being built at Cape Canaveral by Convair. Picture shows *Vega* in launch position.

DECEMBER 7 HEADLINES

Booster Scarcity Stalls Space Effort
It will be two years before the U.S. can match present Soviet space efforts, and it may take many years to catch up 30

San Diego—Much More Than an LA Suburb
A survey shows that the area is heavily involved in components manufacture and important in electronics 25

ASTRONAUTICS ENGINEERING

U.S. Reg. Pdg.

Soviet Rockets Exploit German Technology
An M/R exclusive article by an expert, Donald J. Ritchie of Bendix, tells how the Russians sacrificed ease of fabrication and production to profit from the reliability of the *V-2;* Reds are heavily researching hydrogen-fluorine rockets 17

MISSILE SUPPORT

U.S. Reg. Pdg.

X-Rays Open Up Materials Analysis
Penetrating radiation should provide new market for complete automatic inspection of components. By J. D. Webster, of General Electric 20

Big Static Test Stand Completed at NOTS 21

Hufford Spin Forges Ahead
Firm will have 120″ diameter machine operating by next July; modification could give 150″ capacity 27

ASTRIONICS

West Coast Infrared Symposium Indicates Huge Market Potential 21

Energy Conversion Grows in Importance
New stress on space and potential commercial uses gives impetus to search for more and better ways to convert energy directly to usable electricity 22

NEW MISSILE PRODUCTS

Portable Temperature Chamber Available 34

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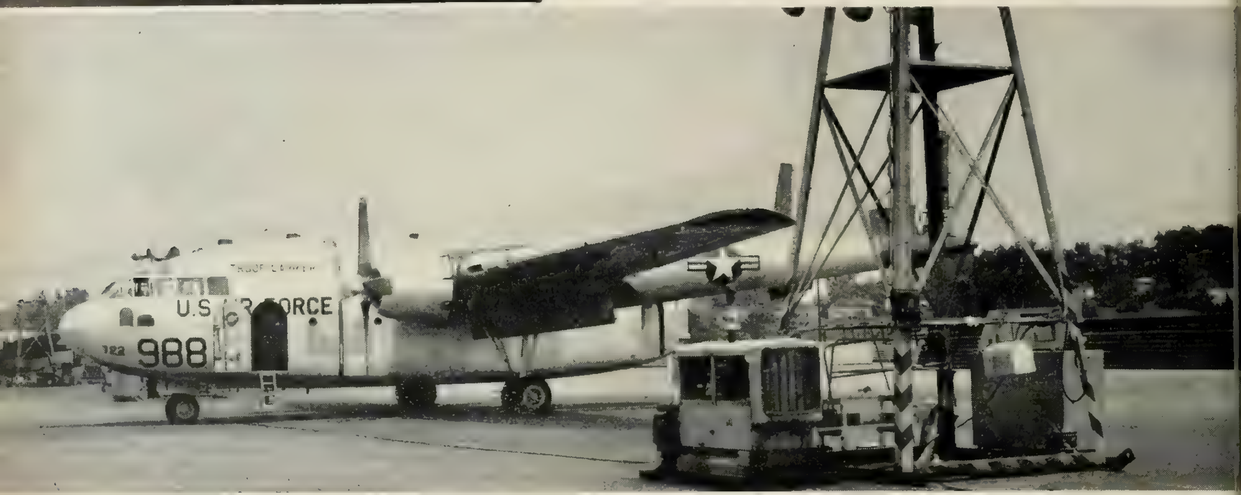

HAYES AIRCRAFT CORPORATION uses Caterpillar power for lighting the flight line. Cat Electric Sets operate 12-18 hours per day, 7 days a week.

At Hayes Aircraft Corporation, Birmingham, Alabama, four Caterpillar D318's and one D315 Electric Set supply power to light flight line area where aircraft are repaired and modified. Only periodic checks are needed to keep these machines in peak operating condition.

At Duluth Air Base, Minnesota, shown at the right, a Caterpillar D337 Electric Set supplies emergency power for all hangar-door electric motors . . . for driving motors on boiler room pumps, blower fans, etc. . . . and for complete lighting.

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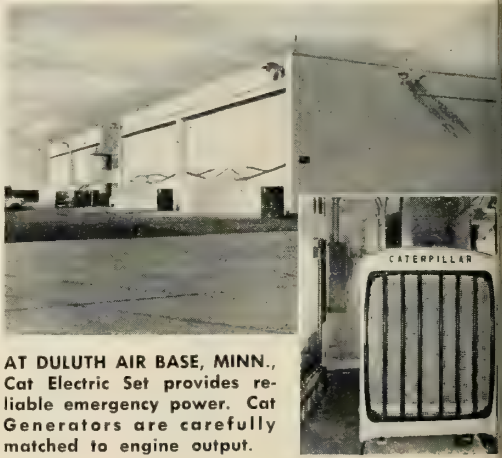
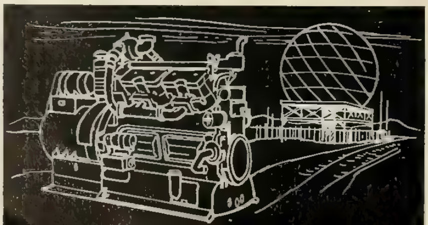


AT DULUTH AIR BASE, MINN., Cat Electric Set provides reliable emergency power. Cat Generators are carefully matched to engine output.

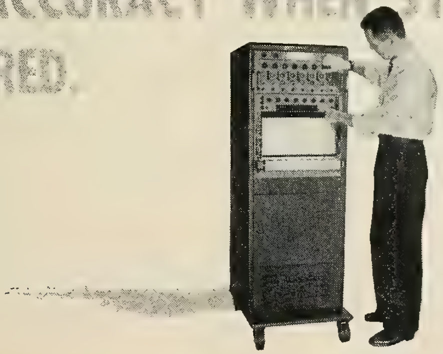
JET ASSIST Caterpillar Portable Electric Sets supply dependable power for starting jet engines and for calibrating control systems.

RADAR BASE Caterpillar Electric Sets furnish power for gap filler sites in our aircraft warning system . . . serve larger bases, too.



LIVING FACILITIES Lighting, heating, air conditioning and base facilities are often powered by Caterpillar Electric Sets.

THE PRACTICAL LOW COST ANSWER TO MULTI-CHANNEL OSCILLOGRAPHIC RECORDING PROBLEMS ··· SANBORN INTRODUCES THE FIRST OF THE 950 SERIES ··· THE 958-1500 SYSTEM ··· FOR FLOATING OR GROUNDED INPUTS FROM 10 μV TO 2 MV PER DIVISION ··· ALL-TRANSISTORIZED ELECTRONICS MOUNTED BEHIND A SINGLE 7" HIGH PANEL ··· FLUSH-FRONT RECORDER WITH 9 ELECTRICALLY-CONTROLLED CHART SPEEDS ··· IMPROVED, RUGGED GALVANOMETERS ··· CLEAR, INKLESS TRACES ··· RECTANGULAR COORDINATE RECORDINGS ··· ALL IN A SYSTEM DESIGNED SPECIFICALLY TO PROVIDE GREATER ECONOMY AND ACCURACY WHEN SYSTEM FLEXIBILITY IS NOT REQUIRED.



Additional features of the "950" Series include: common power supply, built-in MOPA, front and rear inputs, easily serviced plug-in circuit cards, adaptability for use with other readout devices, availability in 4-, 6- or 8-channel models. When many channels are constantly in use for floating or grounded high gain inputs the simplified 958-1500 design assures dependable operation, yet at much lower "per channel" cost.

Complete details are available from Sanborn Sales-Engineering Representatives located in principal cities throughout the U.S., Canada and foreign countries.

SPECIFICATIONS—Model 958-1500 System

INPUT	100,000 ohms, all ranges, floating and guarded.
LINEARITY	±0.4%
SENSITIVITY	10, 20, 50, 100, 200, 500, 1000 and 2000 uv per chart div
COMMON MODE REJECTION	100 db, min. dc
FREQUENCY RESPONSE	0-100 cps within 3 db at 10 div peak to peak. 0-50 cps within 3 db at 50 div peak to peak.
NOISE	¼ div peak to peak maximum.

(All data subject to change without notice)

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Washington Countdown

IN THE PENTAGON

Operational *Hound Dogs* . . .

are scheduled to be deployed first with the 72nd Bomb Wing at Ramey AFB, Puerto Rico. Some of the **North American** air-launched missiles may already be at the base.

• • •

The magic phrase . . .

"stretch out" is the key to military R&D planning within the ever-tightening defense budget. Rather than kill programs, the services will try to conduct a holding operation if at all possible in hopes that a new administration in 1961 will bring policy changes.

• • •

Booming range business . . .

is expected to continue at the Army's White Sands Test Range despite Army's exit from the space business. Some days the rate of firings at the desert range reaches one every 15 minutes.

• • •

ICBM dispersal plans . . .

around Cheyenne, Wyo., call for deploying **Convair** *Atlases* in hardened sites spread over some 11,000 square miles. The layout is similar to the ICBM complex around Salina, Kan.

• • •

Project *Caesar* . . .

the Navy's latest operational submarine detection system, is considered far from what is needed to meet the mounting threat of Soviet missile-launching subs. However, R&D for ASW will continue to be strapped for funds in the new budget.

• • •

Tactical missile shortages . . .

among U.S. Army units in the Far East are causing increasing concern. The reason: The buildup of the tactical missile stockpile of Red China.

ON CAPITOL HILL

Contract renegotiation . . .

will undergo another working over in the new session of Congress—but probably not until spring. A major congressional report on government renegotiation policies under present legislation isn't expected to be completed before then.

A major airing . . .

of the *Nike-Zeus* AICBM program and the whole anti-missile missile defense problem is expected to be ordered by at least one congressional committee. Quite a number of congressmen are reported to find the problem very disturbing—particularly in an election year.

AT NASA

Man in 'space' around Christmas . . .

now appears to be only hope—and a slim one at that—for saving last vestiges of America's disappearing space prestige. NASA plans to send one of the astronauts on a 100-mile flight up (and 100 miles down the Atlantic range) in a capsule atop a *Redstone* this month or next.

• • •

First *Mercury* flights . . .

are far off. New postponements have pushed them back to 1963. This will create an age problem which may eliminate the older astronauts. Lt. Col. John Glenn, the oldest, is 39.

• • •

Vega also is in trouble . . .

The *Atlas* upper stage, which was supposed to be ready next year, now is not scheduled to be operational until the spring of 1961. This is only three months ahead of the high-energy, hydrogen-burning *Centaur*, which is supposed to replace *Vega*.

ALONG EMBASSY ROW

Japan's *Typhoon I* . . .

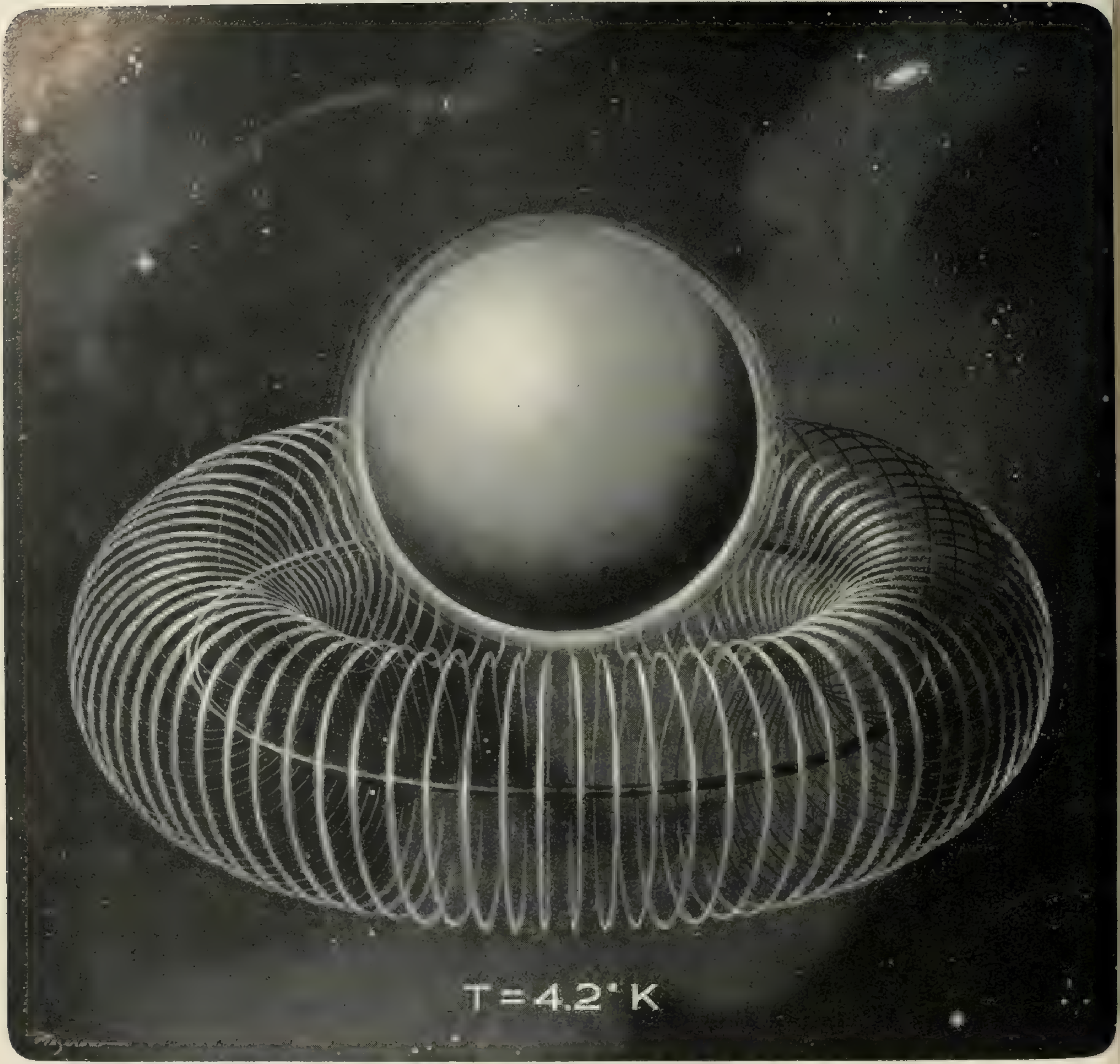
is a camera-armed rocket being developed to photograph typhoons in order to determine their direction and size. The rocket can also be used for general long-range weather reconnaissance work.

• • •

Norway's *Tern* . . .

an anti-submarine missile, is being studied by the Navy for possible purchase. The missile homes on its target with sonar.

IMPORTANT DEVELOPMENTS AT JPL



THE CRYOGENIC GYRO

A fundamentally new type of gyroscope with the possibility of exceptionally low drift rates is currently under development. The design techniques used in conventional electro-mechanical gyros appear to have been largely exploited. A break-through is needed, and the cryogenic gyro may well provide it.

The cryogenic (liquid helium temperatures, in the range of 4°K) gyro consists of a superconducting sphere supported by a magnetic field. The resulting configuration is capable of support in this manner as a result of a unique property of a superconductor. Exceptionally low drift rates should be possible. This cryogenic gyro has performance potential unlimited by the constraints of conventional electro-mechanical gyros.

This is just one example of the intriguing solid state concepts which are being pioneered at JPL for meeting the challenge of space exploration. In addition to gyro applications, superconducting elements are providing computer advances and frictionless bearings. The day of the all-solid-state space probe may be nearer than one realizes.

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Industry Countdown

MANUFACTURING

Puzzler to industry . . .

is Navy's decision to go ahead with a surface-type tender for its long-range nuclear-powered *Polaris* submarines. Many observers feel the fleet ballistic missile subs should have a submersible tender—one that would be difficult for the enemy to track either by air or water. One expert close to the problem tells M/R the Navy wanted an underwater tender, but couldn't find a shipyard that could build it. But the real reason may be cost. The contract for a surface tender awarded **Newport News Shipbuilding & Drydock Co.** recently was for $28.7 million. An underwater tender probably would cost nearly three times as much.

• • •

France's space program . . .

is due for some funding soon. Money is being sought from the French Assembly to allow the National Fund for Scientific Research to carry out space research.

• • •

Various plastics . . .

are being screened for possible use in the *Mercury* man-in-space program by the **Cincinnati Testing Labs Division** of **Studebaker-Packard.** CTL has a new test facility near Cincinnati which can check materials at 4200°F and speeds up to Mach 2.5.

• • •

Several European . . .

nations are expected to buy the British counterpart of the U.S.'s *Sergeant*—the **English Electric** *Blue Water*. Australia is already buying **Bristol/Ferranti** *Bloodhound* anti-aircraft missiles, giving another boost to Britain's growing missile industry.

PROPULSION

Pre-packaged liquid . . .

motor for the improved **Martin** *Bullpup* air-to-surface missile will be interchangeable in the airframe with the present solid motor. This new version is now in production and is expected to be operational with the fleet shortly.

• • •

Combination ramjet-rocket . . .

engine has been patented by the Navy (U.S. 2,912,820.) Combustion heat of the rocket, which is ignited first, burns away a partition before the ramjet cuts in—allowing both chambers to use a common nozzle.

Solid-fueled engine . . .

will be developed by **SEREB** to power France's intermediate range ballistic missile.

ASTRIONICS

Gyro manufacturers . . .

are urging the military to ease up somewhat on rigid specs to reduce costs. Some point out that less than 20% of newly-made gyros meet specs—and against some specs there are yields of 1 in 60.

• • •

Electrostatic gyros . . .

by **Minneapolis-Honeywell** are expected to replace floatation-type gyros in about the fourth stage of the development of SINS (ships inertial navigation system) for *Polaris* submarines.

• • •

Astronertial guidance . . .

is almost certain to be favored over pure inertial system for extended space probes, according to some industry experts. They see the market expanding in the next 3-5 years for the astronertial system. It will correct continuously for gyro drift—and hence is more accurate.

WE HEAR THAT—

The Navy is going . . .

to automatic checkout systems for *Polaris* missiles in a big way. One of the large contractors is **Nortronics** . . . **Fairey Aviation** has a British government contract for new missile development work following cancellation of its *Orange William* anti-tank missile . . . Paris probably will be selected as the site for the International Astronautical Federation's Academy of Astronautics . . . Several Iron Curtain countries are among the 54 nations invited to display their wares at the first International Air and Space Exposition to be held at Los Angeles April 14-24 . . . **Nuclear Materials and Equipment Corp.** has a new process for applying tenacious films of gold directly to substrates without any intermediate steps . . . The "bomber gap" will widen if the Air Force goes ahead in FY 1961 with plans to close or consolidate 15 bases—before the slack can be taken up by more ICBM bases . . . Two **IBM** 705's and one **Burroughs** 220 computer at Norton AFB are handling missile logistics, including 56,000 *Atlas* parts, 35,000 *Thor* parts, and 41,000 *Titan* parts.

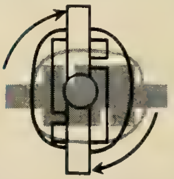
More About the Missile Week on Page 43

Pedigree of a Hound Dog

The guidance and control system of America's HOUND DOG missiles—best of breed—has a pedigree 13 years long. Created by Autonetics, the HOUND DOG's inertial autonavigation system sends this supersonic air-to-surface missile from mother-ship to target anywhere in the world, in any weather. Equipped with an invulnerable sense, HOUND DOG extends the retaliatory effectiveness of SAC's B-52G bombers by hundreds of miles.

Against a 13-year background of blue-ribbon winners, Autonetics is now producing in quantity and at low cost the N5G autonavigator. This is the pedigree that makes the GAM-77 HOUND DOG missile performance "best in show."

DID YOU KNOW?...



At Autonetics, navigation gyros are made so precisely that it would take over 40 years for one to precess one complete revolution.

Inertial navigation by Autonetics

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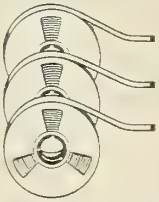
USE LOTS OF TAPE?

"Scotch" brand Instrumentation Tapes cut operating costs

Let's develop our own small theory of relativity. For everything's relative, after all—even economy. Clearly, an economy effected now and *corrected* later is no economy at all. In instrumentation tape, there's only one genuine economy—reliable performance. And in performance, the last two words for any acute tape-user are "Scotch" brand.

First to last, "Scotch" brand Magnetic Tapes offer uniformity and reliability—born of the experienced 3M technology that created the first practical magnetic tape and continues to advance the art of tape-making day by day.

But let's look at economy from another viewpoint—in terms of some things around the periphery that might not come so readily to mind—storage, use, waste, and time saved.



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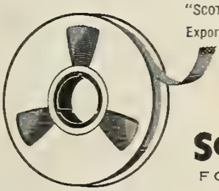

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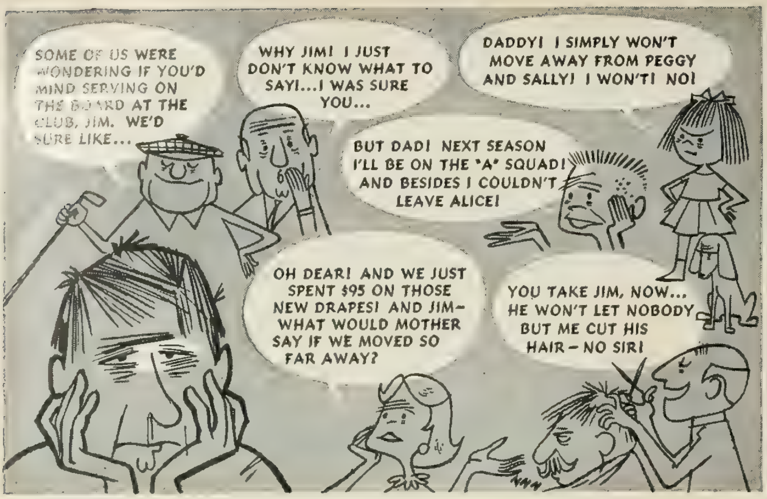
SOME OF US WERE WONDERING IF YOU'D MIND SERVING ON THE BOARD AT THE CLUB, JIM. WE'D SURE LIKE...
WHY JIM! I JUST DON'T KNOW WHAT TO SAY!...I WAS SURE YOU...
DADDY! I SIMPLY WON'T MOVE AWAY FROM PEGGY AND SALLY! I WON'T! NO!
BUT DAD! NEXT SEASON I'LL BE ON THE 'A' SQUAD! AND BESIDES I COULDN'T LEAVE ALICE!
OH DEAR! AND WE JUST SPENT $95 ON THOSE NEW DRAPES! AND JIM— WHAT WOULD MOTHER SAY IF WE MOVED SO FAR AWAY?
YOU TAKE JIM, NOW... HE WON'T LET NOBODY BUT ME CUT HIS HAIR—NO SIR!

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—when and where—

DECEMBER

American Institute of Chemical Engineers, 52nd Annual Meeting, Sheraton-Palace Hotel, San Francisco, Dec. 6-9.

Classified Symposium on The Plasma Sheath, Its Effect on Communication and Detection, Electronics Research Directorate, Air Force Cambridge Research Center, Boston, Dec. 7-8.

American Management Association, Defense Market Briefing Session, Ambassador Hotel, Los Angeles, Dec. 7-9.

Chemical Specialties Manufacturers Association, 46th Annual Meeting, Washington, D.C., Dec. 7-9.

Southwest Society of Aircraft Materials & Process Engineers and Dallas-Fort Worth Branch, American Electroplaters' Society, Hotel Texas, Fort Worth, Dec. 7-9.

American Institute of Electrical Engineers and National Electrical Manufacturers Association, National Conference of the Application of Electrical Insulations, Sheraton Park Hotel, Washington, D.C., Dec. 7-11.

Institute of Environmental Sciences, N.Y. Metropolitan Chapter, Technical Symposium and Product Exhibition, "Instrumentation for the Environment," Henry Hudson Hotel, New York City, Dec. 10-11.

23rd Wright Brothers Lecture; "High Temperatures in Hypersonic Flow—Physical Principles and Experimental Techniques," Natural History Bldg., Smithsonian Institution, Washington, D.C., Dec. 17.

American Chemical Society, Industrial and Engineering Chemistry Division, 1959 Christmas Symposium "Mechanisms of Interfacial Reaction," Shriver Hall, Johns Hopkins University, Baltimore, Dec. 28-29.

JANUARY

Sixth National Symposium on Reliability and Quality Control in Electronics, IRE, EIA, AIEE, ASQC, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

Society of Plastics Engineers, 16th Annual Technical Conference, Conrad-Hilton Hotel, Chicago, Jan. 12-16.

American Astronautical Society, Sixth Annual Meeting, Statler-Hilton Hotel, New York City, Jan. 18-21.

Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York City, Jan. 25-28.

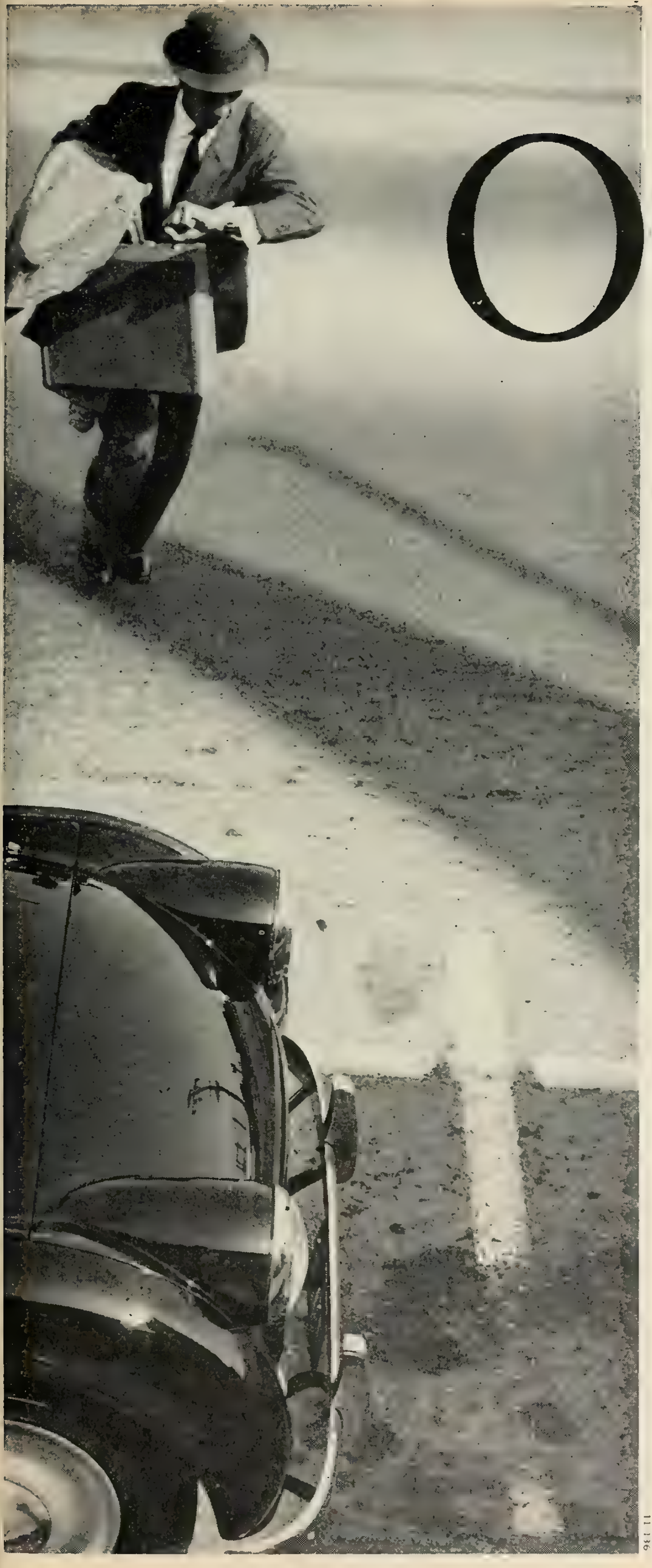
Seventh Annual Western Spectroscopy Conference, Asilomar, Pacific Grove, Calif., Jan. 28-29.

American Rocket Society, Solid Propellants Conference, Princeton University, Princeton, N.J., Jan. 28-29.

FEBRUARY

Chemical Institute of Canada, Toronto Section, Symposium on Gas Chromatography, Seaway Hotel, Toronto, Ont., Feb. 1.

Instrument Society of America, Houston Section, Instrument-Automation Conference and Exhibit, Rice Hotel and Sam Houston Coliseum, Houston, Feb. 1-4.



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"Application of Computer Simulation to Production System Design," a paper by Allen J. Rowe, is available upon request. Send request to Dr. Rowe at SDC.

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Soviet Rockets Exploit German Technology

Sacrifice ease of fabrication, production for reliability of the V-2; Reds research H-F propulsion

by Donald J. Ritchie*

DETROIT—The Russians had a great interest and capability in liquid rocket engines as far back as 1937. So it is unfair to say that all their rocket capability stems from German sources.

Nevertheless, it is accurate to state that Soviet engineers and scientists have taken the German technology and exploited it to its fullest extent.

At the end of World II, the Soviets took over much of German industry, including the tooling for the *V-2* rocket engine. By continuing the manufacture of the *V-2* engine and firing a great many of them, the Soviets have achieved extremely high reliability.

It is well known that experience and usage is the most important single factor in determining the reliability of an engine—or for that matter any other component of a vehicle system. T. Keith Glennan, National Aeronautics and Space Administrator, said recently that the Soviets have probably tested their big workhorse rocket as many times as the total of all tests of big American rockets.

The Soviets sacrificed ease of fabrication and production for the proven reliability of the *V-2* engine—developing ever higher thrusts and better performance without varying the basic type of engine.

The largest known operational Soviet rocket engine is the *R14A*, a scaled-up *V-2* that generates 264,000 lbs. of thrust at sea level. A pair of *R14A* engines, totaling about 528,000 lbs. of thrust, was used as the first stage of dog-carrying *Sputnik II*.

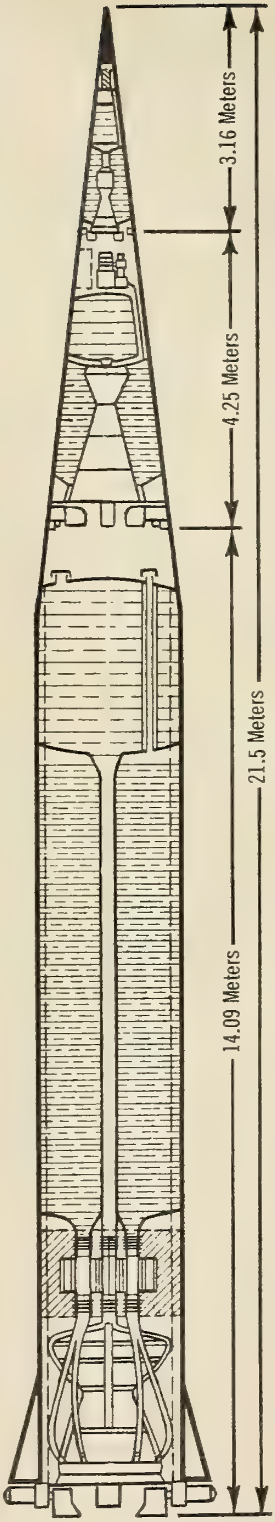
Sputnik I used a pair of the slightly smaller *R14* engines, each with about 220,000 lbs. of thrust. *Luniks I, II* and *III* made use of a cluster of two *R14* engines and two solid-fuel *Golem-3* engines, each with 88,000 lbs. of thrust, for total thrust of about 560,000 lbs.

The Soviets also are known to be hard at work developing nuclear propulsion and high-energy chemical rockets burning hydrogen and fluorine. They have discussed an H-F rocket with a sea level thrust of 281,000 lbs. of thrust as booster for a relatively small vehicle. However, this obviously could be used as a high-energy upper stage of a much larger vehicle system.

In nuclear propulsion, the Soviets have published basic data from which we can infer their interest in a rocket with 550,000 lbs. sea level thrust based on a 13,200 megawatt reactor using liquid hydrogen as a working medium.

Soviet authors, like our own, also have published many highly futuristic propulsion ideas. However, to get a better idea of Soviet progress, it is best to treat it historically.

• **First Red rocket**—V. P. Glushko designed the *ORM-65* engine in 1936. It used nitric acid and kerosene as propellant, developing a thrust that varied from 342 to 386 lbs. It was first successfully flown on a soaring glider on Feb. 11, 1939. Its specific impulse was 210 seconds.



ULTIMATE CHEMICAL propellant combination—hydrogen and fluorine—is exploited in this rocket described in a recent Soviet propulsion textbook.

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* *Donald J. Ritchie, a project mathematician in the Research Laboratories Division, Bendix Aircraft Corp., gathered material for this article by studying hundreds of books and periodicals in the Russian language.*

Large Soviet Liquid Rocket Engine Characteristics

Engine Designation	Soviet V-2	R-10	R-14	R-14A
Sea Level Thrust, pounds	55,000	77,000	220,000	264,000
Vacuum Thrust, pounds	66,500	90,500	262,000	298,000
Chamber Pressure, psi	220	289	850	882
Fuel	75% Alcohol 25% Water	75% Alcohol 25% Water	Kerosene	Kerosene
Oxidizer	Lox	Lox	Lox	Lox
S. L. Specific Impulse, seconds	210	211	242	250
Vacuum Specific Impulse seconds	253	248	288	282
L*	113	113	. . .	.
Propellant Flow Rate, pounds/ second	262	365	910	1056
Nozzle Efficiency Factor	0.973	0.973	0.973	0.973
S. L. Thrust Coefficient	1.32 (1.28)	1.405 (1.367)	1.51 (1.47)	1.56 (1.52)
Vacuum Thrust Coefficient	1.59 (1.55)	1.65 (1.608)	1.80 (1.75)	1.76 (1.71)
Area Ratio	3.42	4.5	16	10
Throat Diameter, inches	15.75	15.75	14.92	15.8
Exit Diameter, inches	29.1	33.4	59.8	50
Chamber Diameter, inches	36.3	36.3	. . .	. . .
Nozzle Length, inches	34.35	45.5	115.5	88
O/F Ratio	1.23	1.23	2.28	2.28

Later the Russians developed the *ZhRD R-3395* for use as an aircraft jato rocket, using nitric acid and aniline, with a thrust of 2640 lbs. Other characteristics of the jato engine are: propellant flow rate, 14.1 lb./sec., specific impulse 188 sec., chamber pressure 396 psi, throat diameter 2.52" exit diameter 5.12", pump feed system and engine weight 125.3 lbs.

After World War II, they modified the German "Walter" engine to use as a fairly high-thrust, throttable aircraft engine. This uses hydrogen peroxide of 80% strength and hydrazine as propellant, producing a thrust varying from 440 to 3300 lbs., with a specific impulse of 190 sec. Its other characteristics are propellant flow rate 17.2-4 lb./sec., chamber pressure 58.7-279 psi, throat diameter 3.31", exit diameter 6.42", pump feed system and engine weight 286 lbs.

Today, there are four primary types of large liquid rocket engines in the Soviet Union. They are the Soviet version of the German *V-2*; an improved *V-2* called the *R-10*; a scaled-up *V-2* called the *R-14*, and an improved version of the latter called the *R-14A*.

The engines were designed respectively for 25, 35, 100 and 120 metric tons of thrust—which in pounds are 55,000, 77,000, 220,000 and 264,000, The *V-2* and *R-10* both operate on watered alcohol and liquid oxygen. The *R-14* and *R-14A* use LOX and kerosene. Table I presents the characteristics of these large engines. In Table II may be found the Soviet rocket vehicles and their powerplants.

The German *V-2*, operating at a chamber pressure of 220 psi, generated 55,000 lbs. of thrust at sea level and 66,500 lbs. in a vacuum. Its specific impulse is 220 seconds. This was improved in the *R-10* to produce 77,000 lbs. at sea level and 90,500 lbs. in vacuum.

The Russians developed the *R-10* easily by using a heavier gauge steel for the combustion chamber, increasing the pressure from 220 to 289 psi and slightly lengthening the nozzle. The area ratio was expanded from 3.42 to about 4.5 to achieve the same coefficient of thrust variation as the engine proceeded from sea level to vacuum conditions. Thrust diameter was maintained but the exit diameter was increased from 29.1" to 33.4". The nozzle efficiency factor remained at 0.973.

• **Performance demands**—As the need arose for much higher thrust liquid rocket engines, a German-Russian team proceeded to design and develop the *R-14* engine, which produces 220,000 pounds of thrust at sea level and 262,000 lbs. at altitude, using a chamber pressure of 850 psi.

The sea level specific impulse of the *R-14* is 242 sec. It is believed that the dry weight is about 2400 lbs. An area ratio of 16 was chosen, which yields a nozzle length of nearly 115", compared with the 45" of the *R-10*.

The *R-14* engine, improved 20% in performance, is designated the *R-14A*. It generates 264,000 lbs. of thrust at sea level, and 298,000 lbs. at altitude with a chamber pressure of 882 psi. The sea level specific impulse of this engine is about 250 seconds.

The area ratio chosen for the *R-14A* is about 10, which yields a nozzle length of 88". The throat diameter is almost identical to the *R-10* engine and has an exit diameter of 50".

In contrast with U.S. practice, the Soviets have retained high values of L* and a multiple cup injector design rather than the U.S. flat plate injector. Furthermore, the propellant turbopumps have been used without change on the Soviet version of the *V-2* engine and the Soviet *R-10* engine. Indications are, however, that the *R-14* engine series uses separate propellant pumps for fuel and oxidizer with a three-pressure cooling system.

The flat plate type construction of the liquid engines has been used throughout all of the operational Soviet engines. However, indications are that research has been carried out on tubular helical wound thrust chambers. It should be remembered that Herman Oberth, a German scientist at Peenemunde during World War II, recommended the use of a wound tubular rocket thrust chamber as a more efficient combustion chamber design.

It should be noted that a cluster of seven of the improved *V-2* engines at 70,560 lbs. of thrust will give a total sea level thrust of 494,000 lbs. This total thrust is very close to the take-off thrust claimed for the *T-3A* booster vehicles.

At the recent American Rocket Society convention in Washington, Soviet scientists denied that they are building more powerful rockets than they now have. However, the reply given by Academician Anatoli Blagonravov was "not just now." Obviously, this leaves much room for maneuver.

• **Higher energy**—Just as in this country, rocketeers in the Soviet Union are interested in harnessing the hydrogen-fluorine reaction, which produces the maximum specific impulse possible in a chemical rocket (398 seconds, frozen equilibrium at sea level). The accompanying diagram shows a three-stage liquid rocket using hydrogen and fluorine as propellants which appeared as an illustration in a recent Russian book on jet engine and rocket propellants.

The first stage would use a large thrust chamber fed by three turbopumps, two of which feed liquid hydrogen to the engine, regeneratively cooling the rocket nozzle. The third and middle pump feeds liquid fluorine. The upper stages have the rocket thrust chamber imbedded in the liquid hydrogen tanks. Small liquid fluorine tanks are mounted on top of the thrust chambers. All stages use an external carbon vane system for control and guidance.

This rocket would have a total length of 70.5', and a diameter of 6.56'. The first stage is 46.2' long, while the two upper stages have lengths of 13.95' and 10.38' respectively. From the extremely small size of the payload in evidence, it seems apparent that this is only a conceptual design. However, it does not seem impossible that Soviet designers might be working on a hydrogen-fluorine rocket for upper-stage use.

Here are the characteristics of the H-F rocket given in the Soviet textbook: sea level thrust 281,000 lbs., vacuum thrust 330,000 lbs., chamber pressure 368 psi, sea level I_{sp} 362 sec., vacuum I_{sp} 426 sec., propellant flow rate 776 lbs./sec., nozzle half angle 18.5°, nozzle efficiency factor 0.9745, area ratio 5, throat diameter 26.5", exit diameter 59.2", chamber diameter 63.9", and nozzle length 51.8°.

• **Harnessing the nucleus**—Two Soviet authors, Sinyarev and Dobrovol'ski, presented a detailed analysis of the nuclear rocket engine in their 1957 book, "Liquid Rocket Engines." Although it is believed that their data is hypothetical, their thinking is undoubtedly an indication of the trend that Soviet nuclear development work will follow.

The authors conclude, just as American researchers have concluded, that atomic and molecular hydrogen provide the highest specific impulses of all working fluids available. They calculate I_{sp} of 822 sec. at 4000°K and 1045 sec. at 6000°K for molecular hydrogen, without dissociation, and 1105 sec. at 4000°K and 1350 sec. at 6000°K for atomic hydrogen, without recombination.

The authors imply that it would be possible to construct a reactor using uranium oxide and graphite operating at a temperature of 2100°K. On this basis, they present possible characteristics of a nuclear rocket engine weighing 66,400 lbs. and generating 550,000 lbs. thrust at sea level and 620,000 lbs. in vacuum.

A nuclear rocket meeting these specifications is obviously several years in the future, both for the Soviets and for this country. However, the characteristics presented for what they may be worth: reactor power 13,200 megawatts, operating pressure 1470 psi (100 atmospheres), average core temperatture 3142°F, gas exit temperature 2942°F, nozzle expansion ratio 20, nozzle efficiency factor 0.973, nozzle half angle 12°, throat diameter 17.35", exit diameter 77.6", nozzle length 113", sea level I_{sp} 472 sec., propellant flow rate 1166 lbs./sec.

The low performance achieved in this powerplant is primarily due to the low fluid working temperature, which is a function of the structural materials available. If one can obtain materials that will stand up at higher temperatures, it is obviously a simple matter to let the nuclear engine heat up the hydrogen a little more and obtain higher performance.

If one assumes a vehicle with a take-off gross weight of 400,000 lbs., this 250 metric ton nuclear rocket engine is capable of placing 43.5 tons into a 300 nautical mile orbit. The useful load placed in orbit is approximately 3000 lbs. This is twice the mass that the *Saturn,* a three-stage chemical rocket vehicle, can place in a similar orbit with a launch weight of 1 million lbs. This points out the great advantage that even a modest improvement specific impulse gives to a rocket vehicle.

• **Futuristic schemes**—Soviet technical literature is rich with proposals for futuristic means of propulsion for space vehicles. Possibilities of ion propulsion, plasma propulsion, nuclear and thermonuclear engines, and photon propulsion, using a scheme of antimatter cancellation, have been considered. Proposals for using lightning balls and beamed electric power for propulsion have also appeared in the literature.

A photon rocket has been proposed wherein a particle and antiparticle accelerator feeds the focus of a large paraboloidal reflector. Matter is annihilated at the focus of the paraboloid, producing energy which propels the photon vehicle through space. The main components of this photon vehicle are the crew cabin, biological shield, nuclear reactor, fuel tank, particle and antiparticle accelerators. With such a vehicle, it is thought that speeds approaching the speed of light can be achieved.

The Soviet engineer and scientist have both the organization and the freedom to carry out research and development in the advanced areas of propulsion for space and travel. They are supported by a singleness of purpose—to put the Soviet Astronaut into space. The Soviet satellites and lunar probes ably point out the success of the Soviets in achieving their goals.

Soviet Rocket Vehicles and Their Power Plants

Vehicle	Weight (Pounds)	Thrust (Pounds)	Probable Engine
V-2	28,400	55,000	1 V-2 Engine
T-1	44,000	77,000	1 R-10 Engine
** T-2 1st Stage	132,000	268,000	1 R-14A Engine
2nd Stage	....	78,000	1 R-10 Engine
* T-3 1st Stage	176,000	440,000	2 R-14 Engines
2nd Stage	....	268,000	1 R-14A Engine
3rd Stage	....	78,000	1 R-10 Engine
T-3A 1st Stage	182,600	518,000	2 R-14A Engines
2nd Stage	....	268,000	1 R-14A Engine
3rd Stage	....	78,000	1 R-10 Engine
T-4 1st Stage	70,840	180,000	2 R-10 Engines
2nd Stage	....	52,800	1 V-2 Engine
CH-9 (Sputnik I)			
1st Stage	....	451,000	2 R-14 Engines
2nd Stage	....	264,000	1 R-14A Engine
3rd Stage	....	77,000	1 R-10 Engine
CH-10 (Sputnik II)			
1st Stage	....	528,000	2 R-14A Engines
2nd Stage	....	268,000	1 R-14A Engine
3rd Stage	....	77,000	1 R-10 Engine
Lunik I, II, III (CH-10)			
Booster	....	176,000	2 S.P. Golem-3 Engines @ 88,000 lb. T.
1st Stage*	184,800	484,000	2 R-14 Engines
2nd Stage**	113,300	410,000	2 R-14 Engines
3rd Stage	24,160	99,000	1 R-10 Engine

American Physical Society Meets at Case Institute

CLEVELAND—The first meeting of the American Physical Society held here in ten years attracted many of the nation's top physicists.

Meeting at the Case Institute of Technology, delegates delivered more than 150 scientific papers in sessions covering a wide spectrum of physical research: theoretical physics, neutron physics, cosmic rays, fission, magnetism and ferroelectricity, metals, semiconductors, paramagnetic resonance, cryogenics, and radiation belt measurements.

AEC Reports Successful Nuclear Reactor for Space

WASHINGTON—A light-weight high-temperature nuclear reactor for space vehicles has been successfully operated at design power and temperature. The SNAP Experimental Reactor, announced by John A. McCone, chairman of the AEC, weighs 220 pounds, without shielding, and is roughly the size of a five-gallon can. It produces sufficient heat to power a three-kilowatt mercury-vapor turbine generator.

The reactor was designed and built for the AEC by **Atomics International** division of **North American Aviation.** Components of a power conversion system to operate from the reactor have been developed by **Thompson Ramo-Wooldridge, Inc.**

X-Rays Opening Up Materials Analysis

Penetrating radiation should provide new market for the complete automatic inspection of all missile and rocket components

by J. D. Webster*

MILWAUKEE—Within the next few years, there will be an unprecedented expansion in the use of penetrating radiation in the missile and rocket field. Penetrating radiation has many distinct advantages. The most important of these are:

- It is non-destructive and at the intensity levels used does not alter the composition of the material examined.
- The instrument using the radiation need not contact the material.
- The characteristics of the material may, in most cases, be measured accurately regardless of physical state.
- Measurements may be taken quickly and accurately.

X-radiation figures importantly in component part manufacture, and in assembly and final test. It can be used to check the amount of fuel, to analyse the fuel itself, for analysis of high temperature metal alloys and for a whole host of related functions.

There are four basic classifications of quality control and analysis in the missile and rockets field:

(1) *Gaging*—Here the mass of the material and hence its thickness is measured by the absorption or scatterings of a beam of radiation.

(2) *Localization*—In this case any abrupt change in the absorption of the material such as would result from an occlusion or flaw is detected. This is similar to the gaging classification but is treated separately as special high resolution detectors are needed.

(3) *Structure analysis*—Here the radiation serves to "finger print" a compound by determining crystal structure that is unique to that compound.

(4) *Elemental analysis*—This permits the utilization of excited secondary radiation to identify certain elements with relative simplicity and at high speed.

These categories cover all uses of penetrating radiation as an inspection or control element in missile and rocket programs.

In specialized applications, through use of point detection devices, one is able to ascertain variations in density within a small area of a normally uniform dense object.

One of these x-ray detectors, a photoconductor cadmium selenide, currently is in use in a semi-automated rocket plant. Here the machine is fed 3.5" rocket charges of cast explosive, and a multiple station mechanical scanning mechanism examines the rocket in its entirety. Each void in the cast charge exceeding ⅛ inch in volume is recorded in one of seven digital computers. When the total void volume exceeds safe limits, the defective region or zone is marked. The rate of inspection is approximately 300 an hour.

- **New system**—Sometimes, higher inspection rates are needed. To fill this need, a new high speed electronic scanning system has been developed, called TVX, which utilizes an x-ray sensitive television camera tube. Here the complete x-ray image of the material being inspected is projected on the face of the special pick-up tube.

Material analysis and penetration radiation dates back to 1912 but it is only recently that x-ray diffraction in missile and rocket work has moved from the research laboratory to the launching pad. Here this equipment serves as a fast and accurate analytical machine requiring only the services of a semi-skilled operator to interpret the data.

The operation is based on the principle that each compound in missiles and rockets has a distinctive crystalline structure which may be accurately determined by using a suitable source of x-radiation to measure the lattice constants. One example of its use as a process control is in determining the life and desirable characteristics of various elements of missile and rocket fuels.

Switching to elemental analysis, we find that one of the most promising innovations here is the x-ray emission spectrometer. The greater simplicity of the x-ray analysis method is due largely to the fact that the characteristic x-ray spectra are relatively simple, consisting of one or two lines while the optical may be made up of several hundred. By calibration with a known sample the intensity of the indication may be used to determine within one percent of relative accuracy the concentration of the element in the test sample.

In projecting future trends, there should be increasing widespread use of penetrating radiation due largely to the demands of continuous flow processes for high speed, non-contacting, accurate and non-destructive control devices.

In gaging, the low energy x-ray generator-detector system is coming more to the foreground. How far this trend continues depends on the ability to instrument to the tolerances required. Systems may be devised which conceivably may assure uniform density in free flow aggregates prior to processing. The x-ray scanning transducer opens up new areas for the complete automatic inspection of all missile and rocket components, limited in application only by the ingenuity of the designer. Material analysis, both as to structure and elemental content, will continue to grow.

**Manager, Industrial Sales*
X-Ray Department
General Electric Company
Milwaukee, Wisconsin

Big Static Test Stand Completed at NOTS

CHINA LAKE, CALIF.—A horizontal rocket engine static test stand capable of handling engines of one million pounds thrust has been completed at the U.S. Naval Ordnance Test Station here.

The $650,000 installation was built primarily for testing of solid-propellant engines for the Navy *Polaris* ballistic missile.

The Navy says the stand is designed to provide a testing accuracy 400% higher than ever before achieved. The static test complex will be able to analyze propulsion characteristics to within .25% error, the Navy says, compared to 1% previously.

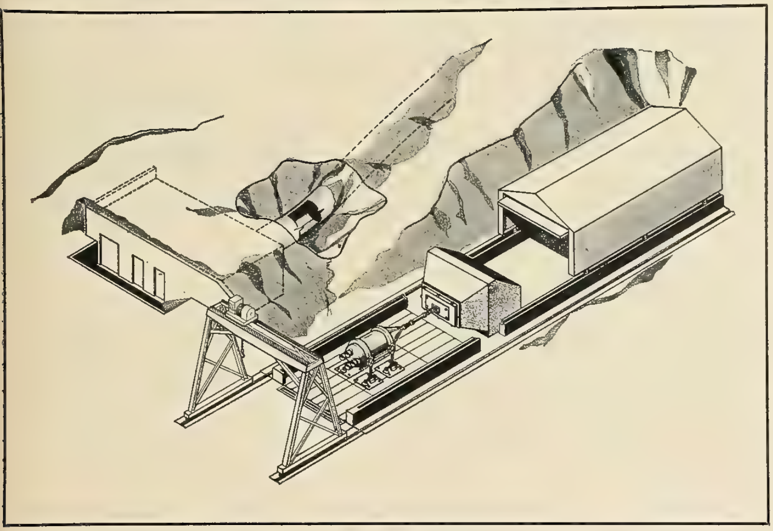
In addition to accommodating engines with an average thrust of one million lbs., the stand will be able to withstand peak loads of 10 million lbs. A test bay 35 feet long and 30 feet wide can accommodate rocket engines six feet in diameter, 30 feet long, and weighing up to 100,000 lbs.

The test complex is located in the Argus mountains.

In testing, the engine will be bolted horizontally to a steel platform, with its nose pushing against instrumentation which in turn will push against 12 inches of solid steel armor plate mounted on a concrete block 13 feet thick and 13 feet high.

A metal shed, which covers the test stand during early countdown to maintain temperature conditioning of the motor, moves away on rails prior to firing.

The firing control and instrumentation building is buried in a hillside a quarter of a mile distant and 37 feet higher than the test stand itself. Both analog and digital recording equipment is housed in this building.



NAVY'S new test stand at China Lake will accommodate engines with an average thrust of one million pounds and peak loads of 10 million pounds.

Infrared Symposium Indicates Field's Value

PASADENA, CALIF.—Infrared market may hit $5 billion by 1965, according to a prediction made at the secret Infrared Information Symposium held here under sponsorship of the Office of Naval Research.

The prediction was supported by turnout at the meeting, which drew more than 850 scientists from the U.S., Canada and Great Britain. Representatives of Army, Navy and Air Force also were on hand for the two-day symposium.

The gathering was the largest infrared information symposium ever held, exceeding expectations by 30%.

In addition to the estimate of $5 billion market by 1965, a spokesman for IRIS said IR should grow to a $500 million field within two years.

All sessions during the meeting were classified, but those who attended told MISSILES & ROCKETS the meeting was "extremely useful" and commented that "we've made some very good progress" in infrared.

While no data on the closed sessions was available, individual companies released some information simultaneously with the meeting.

Hughes Aircraft announced a new type of IR detector for tracking satellites and detecting ICBMs at "extreme" ranges. The detector is a copper-doped germanium crystal operating at liquid hydrogen temperatures and said to be six times as sensitive as existing detectors in the 8 to 25 micron range.

Hughes' new detector is responsive in microseconds to "very small" temperature changes, and the company feels it makes possible the detection of targets at extreme distances. A Joule-Thomson cryostat operating with hydrogen gas and liquid nitrogen was also developed in order to make the detector useful in rugged military equipment.

Subject matter of the classified sessions may be judged from the titles of some of the papers presented:

Low Card (Wright Air Development Center); Spectral Measurements of Missile Plumes (**Perkin-Elmer**); Measurements of Radiation Emitted by Ballistic Missiles During Re-Entry (**Barnes Engineering Co.**); Optical Radiation from ICBM Re-Entry Bodies (**RCA Service Co.**); Infrared Trackers for Ballistic Missile Defense (**Aerojet-General**); InSb Detector Development at the Royal Radar Establishment (RRE, Malvern, England).

Gaseous Infrared MASER Detector (Naval Supersonic Lab, **MIT** and **Block Associates**); Sky Backgrounds Produced by High Altitude Nuclear Bursts (AF Cambridge Research Center); The Infrared Transmissivity of Contrails in the 4 to 5 Micron Region (**Boeing Airplane Co.**); *Project Clinker* (Naval Research Laboratory); Visible and Infrared Spectral and Radiometric Measurements of Solid Propellant Rocket Motors (Boeing Airplane Co.); Missile Flash Measurements (**Ramo Wooldridge**); and Wide Angle Warning System (Santa Barbara Research Center).

Infrared-Tracker Development Progresses

BURBANK, CALIF.—In announcing recently the successful development of an infrared gunsight for West Germany's F-104G *Starfighters*, **Lockheed Aircraft Corp.** also revealed progress in the development of an IR tracking system for missile and aircraft.

Under a current Air Force contract, Lockheed will produce an IR tracking spectrometer to be used as a research tool for measuring target radiation spectral distribution. Observed data will be needed to produce a practical IR early warning unit.

Current schedule indicates that laboratory demonstration of the new unit will be possible within the next few months.

Ultimate goal is a system capable of locating and tracking an IRBM or ICBM within seconds after firing.

Energy Conversion Grows in Importance

New stress on space and potential commercial uses gives impetus to search for more and better ways to convert energy directly to electricity

by Hal Gettings

WASHINGTON—Tremendous strides made in the past few years in energy conversion—changing solar, chemical, and nuclear energy directly into electricity—indicate a growing field of intense interest to both industry and the military.

Recent advances—motivated by military requirements for space power sources in space, land, and undersea vehicles—show exciting potential for further progress. Direct conversion—just a few years ago thought to be neither technically feasible nor practical in usable amounts—has already been brought, in several cases, to the stage of working models.

Here is an area of research and development which would seem to be tailor-made for large segments of industry looking for new fields of endeavor. Increasing military interest—with consequent funding—and possibilities of tremendous commercial application offer an almost ideal combination.

Already at least 1000 companies are involved to some degree; there are estimates that the total may be 10,000 before long. This is no place for a bicycle-shop operation, however. Extensive research and development facilities staffed by experienced and capable people are required. Energy conversion cuts across many disciplines—physics, chemistry, thermodynamics, electronics, solid-state—and may even eventually lead to an entirely new breed of engineer.

In addition, a company needs in-house money to go along with military funding. Present programs indicate that most participating industries are at least matching government money. Several entirely company-funded programs involving large sums have produced significant results.

An interesting sidelight on the growing public interest in energy is the fact that at least one investment fund is devoted entirely to this field. Although the bulk of its $9 million investment is in conventional power sources, nearly 40% is devoted to companies involved in space power applications.

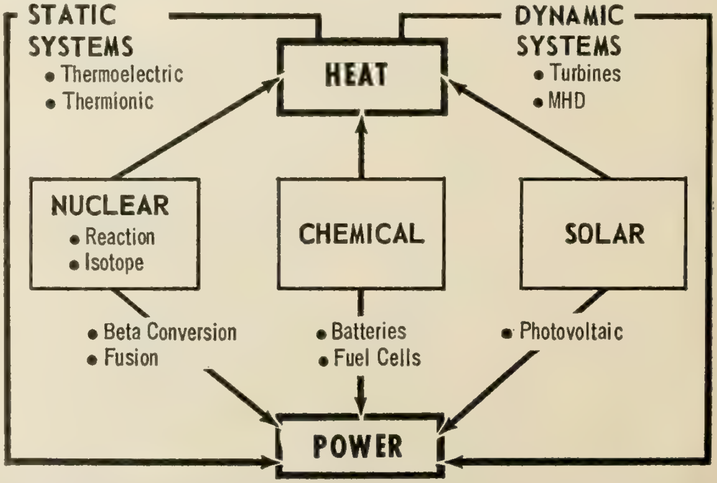
- **Military programs**—The energy conversion problem involves all the military services. New power sources are needed for space, for remote land operations, and for on and under the sea. Consequently, the entire Department of Defense is involved.

Efforts are under way to straighten out what looks, at first glance, to be a magnificent "can of worms." There is considerable optimism that the problems will be solved and that this may perhaps be one of the best-run and most productive military programs.

Research in this area is logically under the Research and Engineering Office of DOD. Total annual funding is now running close to $50 million; it is expected to be about 6% larger in fiscal 1960. Of this amount, $2.4 million is delegated to ARPA. Thirty-seven million dollars is allocated directly to the Army, Navy, and Air Force. About 50% of this is spent for basic research and the other half for applied research and end items. In addition, an estimated $10 million of DOD money is spent for engineering and production of new energy converters for satellite application.

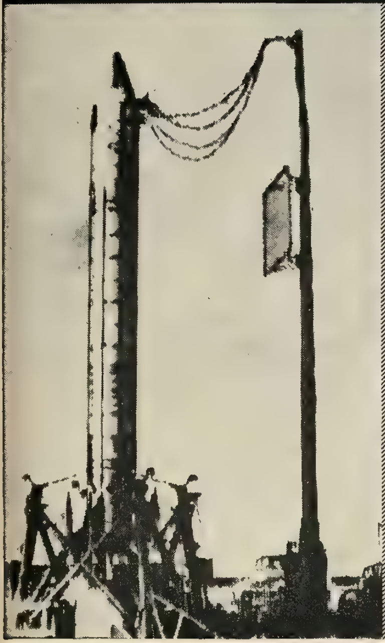
Areas of energy conversion interesting to the military, exclusive of propulsion types, include photo-electricity and photo-chemical (solar systems), thermoelectricity, electrochemical (batteries and fuel cells), and thermionic emission.

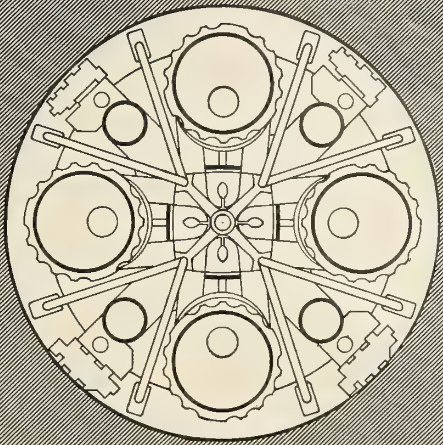
Hopes for a concentrated and correlated push in this area lies mainly with the Interservice Group for Flight Vehicle Power. (This name will likely be changed since the field of energy conversion concerns not only flight but land and sea application. The Interservice Group (ISG) is directed by a steering committee with members from Army, Navy, and Air Force. Representatives from ARPA, NASA, and DOD R&E are associate members. Working areas are categorized into sev-



BASIC ENERGY may be converted into electrical power by both direct and indirect techniques. Direct conversion has now reached the working model stage.

Gamma rocket engine delivers 19,000-lb thrust outside the earth's atmosphere – for a weight of under 700lb . . .





End view showing combustion chambers which can be inclined for vehicle guidance.

...ANOTHER ENGINEERING ADVANCE BY BRISTOL SIDDELEY

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellent rocket engine, the Gamma delivers 16,400-lb thrust (7,438 kg) at sea level rising to 19,000 lb (8,618 kg) outside the earth's atmosphere for a total engine bay weight of under 700 lb.

The Bristol Siddeley Gamma has four gimbal-mounted combustion chambers which are hydraulically actuated for vehicle guidance. Each combustion chamber is fed with propellents by its own turbopump unit and the four units are joined at the centre by a common manifold. The Gamma burns hydrogen peroxide (HTP) with kerosene and uses silver-plated nickel gauze as a catalyst to decompose the HTP into oxygen and superheated steam.

Gamma powers Black Knight

The Bristol Siddeley Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. The Gamma has proved itself to be exceptionally reliable. In fact, in all firings to date Black Knight has never failed to start, and has reached a height of over 500 miles above the Woomera rocket range in Australia.

Since Bristol Siddeley's rocket division began work in 1946 it has developed a wide range of rocket components. By combining these components in single or multi-chamber layouts, thrust requirements from 500 lb up to very high figures, can be met.

BRISTOL SIDDELEY ENGINES LIMITED

BRISTOL AERO-INDUSTRIES LIMITED, 200 INTERNATIONAL AVIATION BUILDING, MONTREAL 3, CANADA

Circle No. 10 on Subscriber Service Card.

eral working groups: advanced methods, batteries, chemical, combustion, electrical, mechanical, nuclear, and solar.

Operation of the ISG is based almost entirely on an informal working agreement. Its primary function is to effect interchange of information and assign work in the various fields among the services best qualified and most needing a particular application. The Navy's Bureau of Ships, for instance, has done extensive work in thermoelectrics, and is considered to have basic responsibility in this area. Army has been assigned fuel cells and solar cells. Air Force's main responsibility is in thermionics.

In spite of its theoretical perfection, the arrangement is not all sweetness and light. There is still a good deal of duplication and overlapping—desirable and otherwise—and perhaps a certain amount of jealousy and competition.

A particular problem is the fact that while all energy conversion is based on certain principles, the end use of the final device determines the direction that R&D must take to produce the end item. For instance, different systems might use the same basic thermoelectric generator but the final devices could differ significantly depending on whether their application was for land, sea, or space. This makes it much harder to assign definite responsibilities and areas to the various services.

One of the first items on ISG's agenda is to set up what will be called a "Power Information Center." It is intended to operate this Center on a contract basis; it will serve as a clearing house for information, conferences, and general administration of the program. The various military services will donate monies to finance it jointly, with later participation by AEC, NASA, and ARPA.

A meeting is being held this month to work out some of the details of the contract, expected to be let shortly after the first of the year. The contract will probably go to some university or non-profit research institution which already has the facilities and people necessary to carry out such a program.

The present chairman of this group is Arthur Daniel of the Army Signal Research and Development Laboratory; the contract for the information center will consequently be handled through the Army.

Another "unofficial" agency involved in this field is called the Advisory Staff for Aircraft Electrical Systems. This group is made up of representatives from various industries in the aircraft and missile fields as well as service representatives. It considers long-range weapons R&D programs and makes proposals for flight vehicle electrical power that will be required in the next five to ten years.

The last report, compiled this summer, goes far beyond aircraft requirements and covers, quite extensively, future requirements for the space and missile field. It emphasizes a strong recommendation for development of energy conversion processes for electric power for satellites. Although some of the recommendations appear to be very "blue-sky," it is estimated that everything suggested would be useful in the next two years—if it were available immediately.

• **Advanced Research Projects Agency**—Up until the present, ARPA has had primary responsibility for space power. This responsibility included formulation of programs and appropriation of money to the various services. However, since ARPA now is allegedly out of the space business, its future position appears somewhat fuzzy. Indications are that ARPA will assume a role of supervision for an advanced research program, leaving hardware development in the hands of the military forces.

Previously, ARPA had its own funds from DOD and appropriated them to various government agencies who did their own contracting. In Fiscal '59 the program involved $2.5 million; in '60 it was scheduled to be $3 million. It appears likely that some of the ARPA portion of the program will be turned over to the Air Force, which henceforth will administer the program as it applies to space.

• **National Aeronautics and Space Administration**—For Fiscal Year '60, NASA has responsibility for approximately $2.5 million for work in energy conversion. The bulk of this work is in solar cells and applications; the rest is on regenerative fuel cells. NASA expects shortly to inaugurate a solar-mechanical and solar-thermionic program and also give some support to photovoltaic techniques. It is expected that NASA will participate in the interservice group and their stated intention is to coordinate to preclude any duplication or overlap. The space agency's work is aimed directly at space requirements with interest primarily in systems of 1 to 300 lbs/kw for a few kilowatt power demand.

• **Atomic Energy Commission**—The AEC has its own budget appropriations, and most of the work in this area has gone into what is called the SNAP program. In Fiscal '59 this amounted to $13.1 million and in Fiscal '60, $14.3 million. This program has already produced some significant results. One so-called atomic battery, SNAP III, was first shown almost a year ago. Just last week a working model of SNAP II was displayed at the annual American Rocket Society meeting. This was a reactor capable of furnishing heat for production of three kilowatts electric power for space vehicles. It weighs approximately 220 lbs. without shielding and is fueled with enriched uranium. The SNAP III unit was a small isotope power device using a thermoelectric generator to produce small amounts of power.

• **Air Force**—The Air Research and Development Command has primary responsibility for carrying out the Air Force energy conversion program. In Fiscal '60 they had approximately $16 million to spend, and for Fiscal '61 will have an estimated $15 million. ARDC is involved in both basic research (AF Cambridge Research Center) and applied research (Ballistic Missile Division).

It is also understood that BMD will be responsible for programs turned over to the Air Force by ARPA. This has its problems, however, as well as inconsistencies. For one thing, BMD is under ARDC. For another, BMD at present has no technical management organization sufficient to carry out this program. It may be that the program at Wright Air Development Center and at BMD will be coordinated and enlarged to handle this technical management responsibility.

Present AF budget is divided on the following basis: solar, $4.5 million; nuclear, $2.5 million; nucleonics, $1.5 million; fuel cells, $1.3 million; fluids research, $1 million; advanced analysis $1 million; and a miscellaneous category of $4 million, most of which is actually for the B-70 and not applicable to the missile or space program.

The Cambridge Research Center will be managed by the Research Division of ARDC, which until the recent reorganization was the Office of Scientific Research. It is expected that it will probably be the end of this month before a firm program and mission assignment is set up—and possibly next spring before BMD is equipped to handle the program.

• **Navy**—The Navy's program of energy conversion is scattered among several agencies: Office of Naval Research, Naval Research Laboratory, BuShips and, to a small extent, BuWeap. Navy requirements are, of course, not in space but are in closely related areas as far as energy is concerned. It has in

(continued on page 42)

San Diego Is More Than LA Suburb

M/R survey finds area heavy in component manufacture and electronics work; some officials worry over reliance on military work

by Frank G. McGuire

San Diego, Calif.—Often thought of by out-of-staters as a suburb of Los Angeles, this thriving city in southernmost California actually is, in its own right, a major factor in the Nation's aircraft/missile/space program.

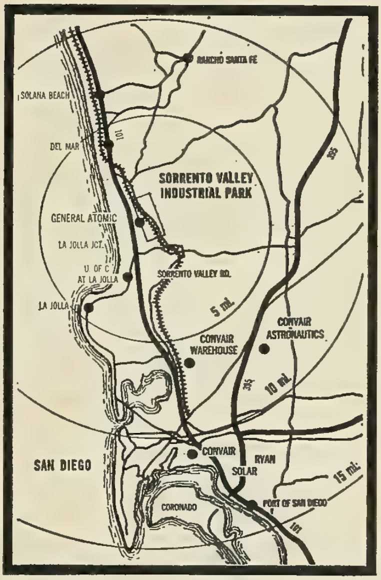
It has some of the largest aircraft and components plants in the world, the biggest concentration of naval strength on the West Coast, and a goodly portion of the electronics industry. Its workers have built the free world's first ICBM, some of the fastest U.S. jet fighters and drones, and what is billed as the fastest jet airliner in the world.

Greater San Diego has a population hovering around one million, ranking twentieth in the Census Bureau's list of standard metropolitan areas. Its population climbed 61% from 1950 to 1958. The 193-square-mile city has an an excellent climate—10 inches average annual rainfall and a daily temperature range of 54.5 to 70.2°.

- **Defense-dependent**—Of the 75,000 manufacturing employes in San Diego, 57,500 are in aircraft/missile payrolls—35,650 at **Convair Division, General Dynamics Corp.;** 11,050 at **Rohr Aircraft Corp.;** 6700 at **Ryan Aeronautical Co.;** 2200 at **Solar Aircraft Co.,** and the rest at other companies.

Many city officials have been decrying this lopsided dependence on aircraft/missiles and the military establishments in the area. "But for the success of the *Atlas* ICBM," says economist Eastman Hackney in *San Diego Magazine,* "San Diego still would be floundering in the doldrums of the 1957-58 recession." A number of study groups have been set up to find ways to diversify the area's expanding industry.

- **The run-down**—Convair, with its Astronautics and San Diego divisions, is the mainstay of the San Diego economy; the two divisions employ almost half the city's manufacturing workers. Other units of General Dynamics are **General Atomics,** at La Jolla, where 400 employes occupy a $10-million facility designated the John Jay Hopkins Laboratory; **Stromberg-Carlson,** which expects its SD facilities ultimately to be as big as those at its Rochester, N.Y., headquarters; and **Liquid Carbonic,** which has opened a new plant in the Kearney Mesa Area.



EXAMPLE OF booming real estate in San Diego area is Sorrento Valley Industrial Park 10 miles north of city.

Convair (Astronautics) occupies a $40-million facility at Kearney Mesa, an area north and west of the city. The multi-unit plant is reputed to be "the largest, newest and most modern facility in the free world for integrated research, development and production of long-range missiles and space vehicles." Two six-story office and engineering buildings are coupled with an 834-foot-long factory building to provide this capability.

Rohr Aircraft Corp., the largest manufacturer of flight components, turns out bonded structures for the *Hound Dog* pylon, but has no other missile projects now underway. About 68% of Rohr's business is in commercial aircraft components.

Ryan Aeronautical Co., a $74-million-gross business in 1958, is deep in production of aircraft/missile components, jet target drones, electronics and navigation equipment, rocket engines and frames, as well as research and development work. Employment totals about 6700 with the great majority at the San Diego plants, located on a 48-acre site at the city's Lindbergh Field.

Ryan's drones have been almost standard items at air gunnery competitions including the recent William Tell II worldwide gunnery meet. To supplant its Q-24 drones, the company is producing the Q-2C version, capable of transonic speeds at over 50,000 feet altitude.

Explosive forming is another field in which Ryan is a leader; it is producing complex shapes to extreme tolerances with small explosive charges, and expects to put the technique to extensive use in component fabrication.

Lightweight steel structures, dubbed "MiniWate," are also being developed, with a view toward creation of extremely lightweight vehicles for aerial and space applications. The secret of the method lies in corrugation patterns.

Solar Aircraft Company, which recently closed its Des Moines facility, is working on advanced types of thrust chambers, nose cones, motor cases, valve systems, and other subsystems.

Some of the projects which Solar now has "in house" are for ARPA, NASA and various prime contractors on missile systems. The company aims to establish as firm a role in the missile/space field as it has enjoyed in aircraft.

California General, one of the component producers in the area, has been turning out *Polaris* nozzles and other vital missile components at its Chula Vista plants. Experienced in working with refractory and exotic metals, CG has subcontracted on a number of missile projects.

Langley Corporation, specializing in hydraulic and pneumatic components, has been engaged in fuel and oxidizer handling and internal systems, cryogenic cleaning and various other services in the field. The 12-year-old company produced early-model *Atlas* fuel connections which have achieved operational status.

• **Small but able**—Electronics is a sizable business in San Diego, but not with the huge plants that characterize other electronic-industry areas. The great majority of electronics facilities here are relatively small, but their competence is reflected in their sales volumes.

Stromberg-Carlson produces four kinds of electronic products: equipment components (display tubes and deflection yokes, special purpose tubes, transistor and DC servo amplifiers); system components (airborne missile release computers); independent equipment (test devices for automatic checkout of missiles); and complete systems (high-speed editing, display and recording of computer information).

The San Diego plant of SC employs 400 people and occupies a 53,000-square-foot pair of buildings.

Electronics divisions within aircraft companies are a growing trend, and San Diego has its share of these. Convair, Ryan and other old-line aircraft manufacturers have gone into the electronics field and established facilities here.

Non Linear Systems, Inc., originators of the digital voltmeter, have occupied buildings located at Del Mar airport, a few miles north of San Diego. The company began operations about 1952, with production of the first digital voltmeter, and has been a leader in the digital instrument field. NLS has utilized plug-in modular construction and "no-needless-nines" logic in its products, in which the latter technique contributes to speed.

Daystrom Systems recently constructed a plant in La Jolla for production of automated systems, including power information, petroleum systems analysis, steel process control and nucleonics data collection.

Electro Instruments produces 80% of its products for inclusion in missile ground support equipment. The company turns out digital measuring instruments, graphic data recorders and precision amplifiers in a 43,000-square-foot plant on Kearney Mesa.

Hughes Aviation has entered the San Diego area electronics picture with the purchase of **Vacuum Tube Products Co.,** producers of special cathode ray tubes, storage tubes, vacuum measuring devices and other equipment.

Humphrey, Inc., suppliers of stabilizing gyros for rocket vehicles, also has in production a number of other instrumentation components for missiles. The company has enjoyed excellent growth in the field.

Cohu Electronics, a diversified company best known for its TV systems, has three divisions producing many types of amplifiers, meters, cameras (TV), remote controls, power supplies, hydrophones, sonar transducers, ultrasonic equipment, recorders, accelerometers, and a great number of other items.

The 15-year-old company consists of **Kin-Tel, Massa** and **Millivac** divisions, with the Kin-Tel division located in San Diego. Kin-Tel is one of the biggest names in closed-circuit television systems, although it also produces other items such as power supplies, amplifiers and various types of meters.

Cubic Corporation caused a flurry of stock activity in August when it issued over 100,000 shares of stock at $12 per share, which sold at $20 before the day's end. Producers of digital test equipment, data-handling systems and other electronic equipment, the firm sells 90% of its products to government agencies.

Kinetics Corp., located north of San Diego in Solana Beach, has climbed from 3 to 100 employees in less than three years. The six months period ending July 31 saw over $500,000 in sales recorded.

The company develops and produces telemetry equipment, including commutators and inverters. It was organized in February, 1957, and recently moved into a 20,000-square-foot plant.

Molectrics of San Diego, Inc., affiliated with an Inglewood firm of similar name, has been formed to engage in electrolytic machining and electropolishing of metals. The company will work principally on stainless steels for missile applications, as well as aluminum, titanium and chrome.

Stellardyne Laboratories, engaging in test of missile components, is a wholly-owned subsidiary of **Central Hadley Corp.** and has sales volumes over $1 million annually. The laboratory is one of the five largest environmental test labs in the country, despite the fact that it is just over two years old. It conducts more than 800 tests monthly, with missile components making up 80% of this volume. The company is diversifying into research activities, LOX cleaning and packaging, and other areas.

Real estate activities are booming throughout the San Diego area, with a number of industrial parks and other developments being promoted. One of the largest is Sorrento Valley Industrial Park, ten miles north of downtown San Diego. The valley will contain 780 acres of industrial tracts, straddling the Santa Fe Railroad's main line, and near the Route 101 freeway. The park lies within San Diego city limits and is served by local telephone and other utilities.

Kearney Mesa industrial park, being developed by the city, is a 450-acre tract lying between Convair-Astronautics and Montgomery Airport. **Narmco Resins & Coatings** has located in this tract, a supplement to its Costa Mesa facilities.

Devices Could Handle 300 Million Words/Sec.

NEW YORK—Electronic devices capable of handling information at the rate of 30 million words a second were reported here recently by a **Sperry Gyroscope** engineer at a meeting of the IRE Professional Group on Electronic Computers. At this rate all of the news material in 200 large daily newspapers could be transmitted in less than one second.

The new devices were created for developing computers and communications systems capable of handling large amounts of information at speeds at least 1000 times faster than large electronic computers currently in use.

Early use of these new high-speed techniques will probably be in systems simpler than computers, however. One possibility would be in a special communications system in which a message of 30 words could be transmitted in a millionth of a second. Such a system could transmit the complete message on a single radar pulse.

Another potential use is in a data reduction system involving simple operations such as correlating and counting where billions of events occur in an extremely short time.

Sperry scientists foresee this capability as a vital factor in future defense weapons in addition to providing a powful tool for accelerating advancement of science and technology.

Hufford: Spin-Forging Ahead

Firm will have 120″ diameter machine operating by next July; modification could give 150″ capacity; no help from the government

by Frank G. McGuire

Los Angeles—When the world's largest shear-forming machine—Hufford's 120″ diameter Spin Forge—goes into operation here next July, it will give the missile industry unprecedented ability to make structural sections having any surface of revolution.

Hufford Division of **Siegler Corp.** will use the giant to produce complex shapes as big as 120″ diameter and 300″ length. This will involve more considerations than metal working: a special power substation, a five-story building to house the machine, a 12½-foot-deep concrete foundation, and all the other complications involved in building and operating a 560,000-pound machine.

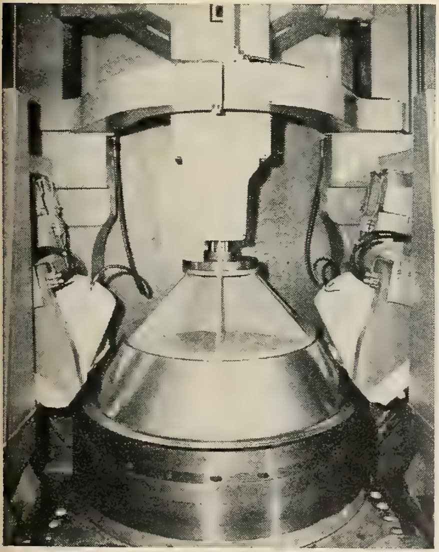
Despite estimates that the industry is not likely to require diameters over 120″, Hufford has designed a 150″-diameter potential into its new Spin Forge; it could be realized with little modification. The $1-million machine will be available to industry on a subcontract basis, and Hufford expects that the Spin Forge will be kept quite busy.

Materials for the 120″ unit will be about 60% steel plate and 40% steel castings. The costs are being borne by the company without government investment. Overall size of the Spin Forge is 310″ high, 440″ wide and 260″ deep, exclusive of the foundation dimensions.

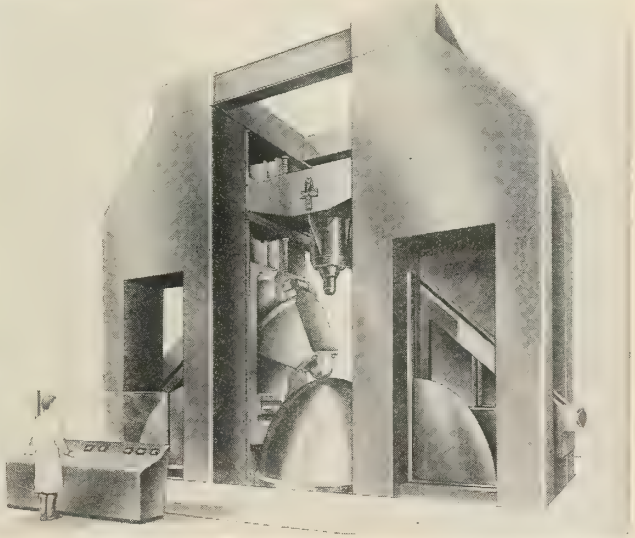
In order to accommodate the machine, Hufford will rebuild one of its present buildings into a five-story bay specifically designed for the purpose. Special mercury-vapor lights will be installed because standard lighting will not penetrate from the ceiling to the floor of the building. Reconstruction will cost $250,000.

- **How it works**—Control of the machine is accomplished through a hydraulic/electric system that is completely transistorized. It operates the Spin Forge through 360° on two axes. An electronic tracing head with stylus traces the template, and is coupled to an oil gear variable volume pump by an electro/hydraulic servo valve. This valve controls the output volume of the actuating system pump, and thus exerts control over the tool rings of the Spin Forge.

Two pump units are controlled by the double-axis tracer, one for vertical movement and another for horizontal movement. The tool rings are continuously synchronized. In conjunction with the spindle tachometer, the control system maintains a constant feed



HUFFORD'S 60″ diameter Spin Forge is already in operation turning out parts like this.



ARTIST'S DRAWING of the 120″ diameter machine scheduled to be available for subcontract work by July, 1960. A building is being rebuilt to hold it.

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per revolution and a constant surface speed.

Heating elements within the mandrel can maintain the preform workpiece at up to 1000°F during the forming operation, in order to conduct the operation under the best metallurgical advantage. The Spin Forge is capable of applying one million psi to the preform during spindle operation from zero to 300 rpm.

Capable of turning a surface with varying wall-thickness, the 120" Spin Forge will maintain tolerances of .002". (Tolerances achieved on previous Spin Forge models were closer to .003".) Total power input will be about 2000 HP, supplied from the substation to be built by the **Edison Co.**

The most apt description of the Spin Forge process is that supplied by Dan W. Burns, president of Hufford: "It's just like clay on a potter's wheel—you place material on the spindle, rotate it, and work against it with tools during rotation." In operation, the Spin Forge handles metal as easily as a potter handles clay.

During production, a metal preform is placed on the mandrel and held in place by a vertical tailstock or hydraulic ram. The spindle is then rotated at speeds up to 300 rpm, and two massive tool-steel working rollers, exerting up to one million psi, move in to force the metal down and over the mandrel form. Under such great pressure, the metal "flows" and the grain characteristics change to provide superior alignment.

• **Many advantages**—According to Burns, one of the best features of the Spin Forge process is its ability to produce varying wall-thicknesses in sections like cones, hemispheres, cylinders, and paraboloid shapes. There are a number of other significant advantages: production of high-strength cylinders without longitudinal welds; improvement of physical properties of metals by simulating continuous forging; increasing tensile strengths by orientation and refinement of granular structure; revealing defects immediately, and revealing non-metallic inclusions in materials.

One of the non-physical advantages of the method is time saving. An example is fabrication techniques used in production of center-section structures for pressure vessels. A motor casing section made with the wrap-and-weld method, 100 by 50 inches, has a generally accepted production cycle of four hours. Roll forming the same section on a Spin Forge would require five minutes, plus handling time.

This 100-inch-long tube would be produced by placing a "doughnut" of metal on the Spin Forge mandrel, and by utilizing the tremendous force of the work rollers, cause the metal to "flow" vertically. A metallic ring 25" high, with a ¾" wall thickness and 50" inside diameter, would produce a 100" long cylinder with a 3/16" wall thickness. Finishing would be required only at the open ends, where welds might be desired.

Hufford, a 225-employe firm, was established in 1941, and has pioneered the Spin Forge process in the aircraft/-missile industry. The Spin Forge is currently being used in experimental production of first-stage engine forward domes for *Polaris*, which Hufford is making for **Aerojet-General**, propulsion subcontractor to **Lockheed**. The company is also making a limited number of *Polaris* equipment sections directly for Lockheed under a study contract.

Saturn booster bulkheads for propellant tanks are also being turned out on the Spin Forge machine at Hufford. A considerable number have already been delivered to the Army's Redstone Arsenal for fabrication.

Originally engaged only in production of stretch-forming equipment for the aircraft industry, Hufford has accounted for more than 85% of the world's stretch-wrap forming equipment and accessories.

Bureau of Standards Backs Plasma Study

WASHINGTON—A theoretical research study aimed at solving the basic problems in plasma physics is under way at the National Bureau of Standards.

The work is sponsored by the Air Research and Development Command. Part of it will involve establishing sound foundations for plasma theory.

A quantum theoretical generalization using the methods of quantum collision theory is being developed, and relativity considerations will be included later to arrive at a formulation which will apply to cases where electrons attain relativistic energies.

Wyman-Gordon Shows All-Beta Titanium Alloy

WASHINGTON—A 441-lb. closed-die forging of B120 VCA all-beta titanium alloy was shown here recently by the **Wyman-Gordon Co.**

B120 VCA also contains vanadium, chromium and aluminum. Wyman-Gordon said the alloy as forged develops 180,000-200,000 psi yield strength with 4% to 6% elongation. The 41.16" diameter forging was shown at the Eastern National Astronautical Exposition, held in conjunction with the American Rocket Society meeting.

The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment. Some immediate openings are described on the facing page. Please read it carefully.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of

DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

Booster Scarcity Halts Space Effort

It will be two years before U.S. can match present Soviet space efforts, and many more years before it can hope to catch up

by C. Paul Means

WASHINGTON—The wake of Nov. 26's ill-fated *Atlas-Able* moon shot produced the public admission that the nation's belated, underfunded space effort has reached a dead end because no large boosters are left to get its ambitious projects off the ground.

The failure emphasized that the U.S. is at least two years away from matching present Soviet space feats, and past history has shown that the Russians will not stand still during this period. Present estimates indicate it could well be the latter half of the next decade before the U.S. space effort catches up.

A year-end inventory of the U.S. space program reveals these facts:

- All *Atlases* under production—the only boosters presently capable of lifting large payloads into space—are committed to military/missile space programs, and to the man-in-space program, Project *Mercury*.
- Lead time on new *Atlases* if ordered today is 18 months—15 months under a crash program.
- Scheduling is a great problem because only one *Atlas* launching pad capable of handling upper stages is in working order.
- Future U.S. space vehicles capable of matching *present* Soviet space feats—*Vega* and *Centaur*—will not be ready until the spring and summer of 1961 respectively.

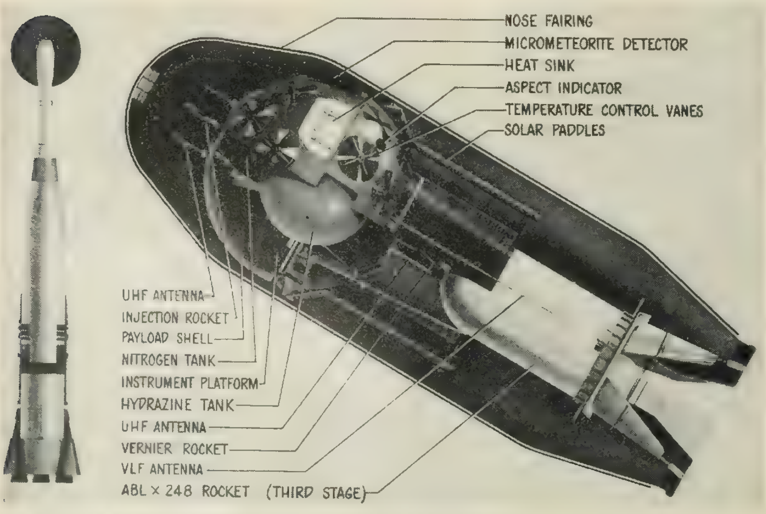
• **$15 million down the drain?**—An example of NASA's present dilemma is the moon-orbiter project on which close to $15 million has already been spent.

Originally scheduled by ARPA, the moon orbiter's initial goal was to send a payload to Venus last June. This goal was set before scientists had determined the astronomical unit.

When the vehicle's payload was not ready by that time, NASA decided to orbit the moon with the payload in October. This attempt ended in late September when an *Atlas* Booster—the only booster given to the project—blew up during static test. The explosion also damaged one of the two *Atlas* pads capable of launching the booster with added stages.

NASA then became lucky when its meager inventory produced another *Atlas:* two *Atlases* were designated for Project *Mercury's Big Joe* experiment, but one proved to be enough. The second *Big Joe Atlas* was used for the belated Thanksgiving attempt.

NASA has another payload, but not another booster. It is therefore possible that the almost $15 million spent will go down the drain.



PAYLOAD **aboard unsuccessful** *Atlas-Able* **moon rocket.**

The space agency could divert an *Atlas* from Project *Mercury*, but to do so would further delay the important man-in-space program, already pushed back until 1963.

If NASA finds that Project *Mercury* could do with one less *Atlas*, it would take **Convair** approximately two months to modify the *Atlas* and place the three-stage **Space Technology Laboratories'** *Able* upper stage and guidance system on top, a Convair official said.

But even if an *Atlas-Able* were ready in two months, a launching pad would not be available. The one launching pad at Cape Canaveral capable of handling an *Atlas* with upper staging must also be used for military *Atlas* ICBM tests as well as for Project *Mercury*. Average time that a launching pad is tied up for one specific shot is four to six weeks.

If NASA cannot spare one of its Project *Mercury* boosters, then it would have to scrape enough money out of its meager fund to buy more *Atlases*. It takes Convair 12 months to build one of the boosters, but lead time from order to launch is 18 months. This could be trimmed to 15 months on a crash program, M/R was told.

• **Marginal chances**—The final reason that an *Atlas-Able* will probably never be used to launch this particular moon-orbiting payload is that many NASA officials have serious doubts whether the vehicle could accomplish the mission.

The *Atlas-Able*—many in NASA say—is an interim vehicle that is being used as a stop-gap until *Vega* and *Centaur* come along and its chances of completing the moon-orbiting project are marginal. NASA is presently considering whether it is worth expending another *Atlas* booster and launch pad time to try again.

The cost of the *Atlas*, launch crew and launch expense would be about $4 million, bringing the total expense of the program close to $19 million. If NASA had to buy another *Able*, the cost would be greater.

One advanced concept for *Atlas-Able*, known as *Nomad*, has been suggested, however. It would ultimately use a fluorine-hydrazine final stage which proponents say would place a 1100-1200 lb. softlanding payload on the moon within 18-24 months from project go-ahead.

With *Vega* and *Centaur* two years away from the launch pad, the U.S. space program for the immediate future—regardless of how much money Congress appropriates for space—is limited.

The only major upcoming shot is an attempt to place a *Thor-Able* (Dec. 10) into a sun orbit. This vehicle has the capability of sending information from as far as 50 million miles in space.

Shots planned for the next six months include:

- An attempt to send an astronaut 100 miles up and 100 miles down the Atlantic Missile Range atop a *Redstone;*
- Project *Tiros,* a *Thor-Able*-boosted meteorological payload which would take top-side pictures of the earth's cloud cover;
- Preliminary Project *Mercury* shots sending dead and animal payloads into orbit.

The latter half of 1960 will bring satellite orbit attempts with the new solid-fuel *Scout* and *Thor-Able's* successor, *Thor-Delta. Thor-Delta* conceivably could be useed for a moon-orbit attempt, carrying 100 pounds of payload, 35 pounds of which would be retro-rocket.

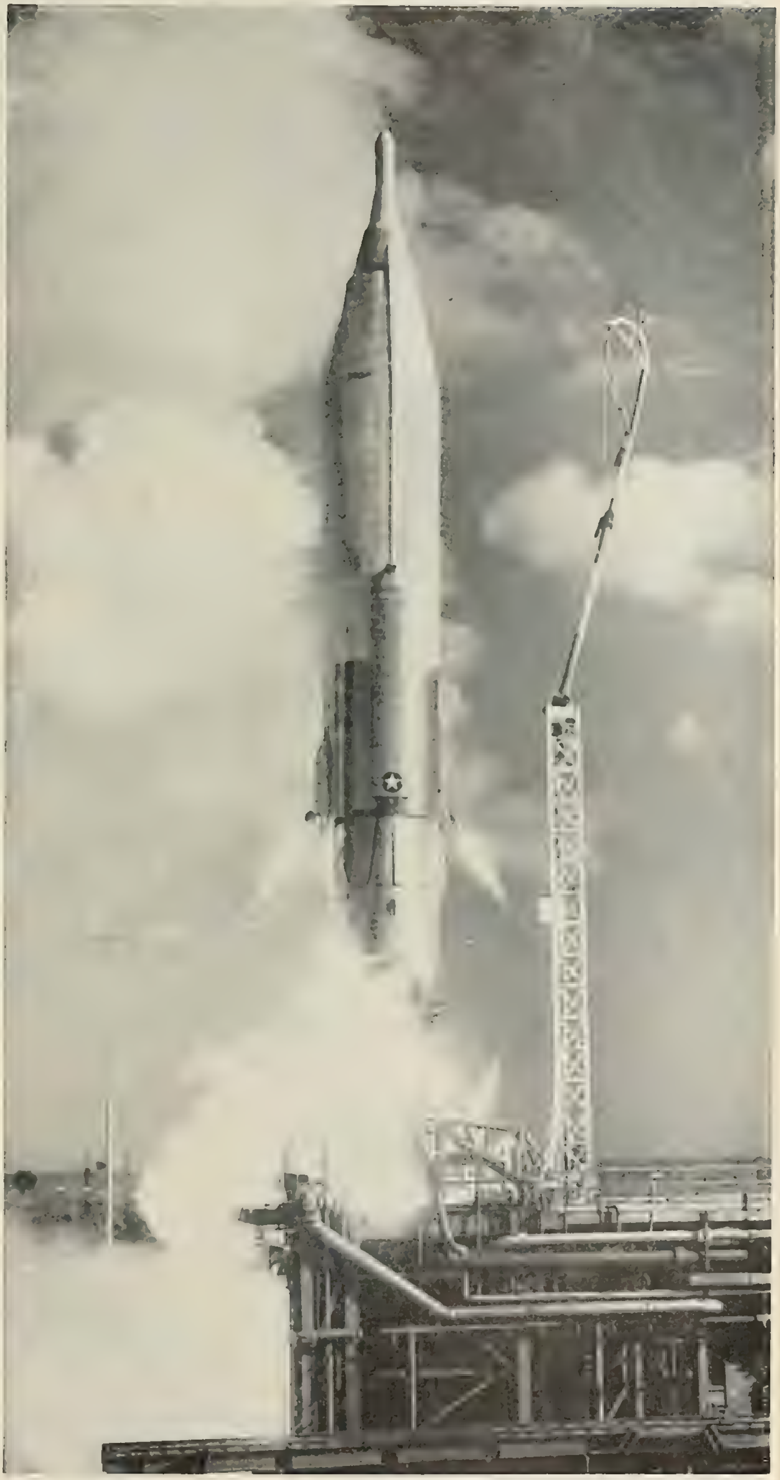
But until the *Vegas* and *Centaurs* are poised on the launching pad two years from now, no major space shots with the payload capability of *Mechtas II* and *III* will be attempted by this country.

One job the *Atlas-Able* or *Thor-Delta* will have to attempt is a Mars shot toward the end of 1960. The astronomical cycle for near planet probes is so long that the space agency will have to make the try with inadequate vehicles or wait many years.

- **Space program**—How can the United States overcome the present Russian space advantage? Most space authorities talked to by M/R reporters last week said the first hurdle is money. Our space program is inadequate now because of a lack of funds two years ago. Money spent now will not enhance our position until two years from now.

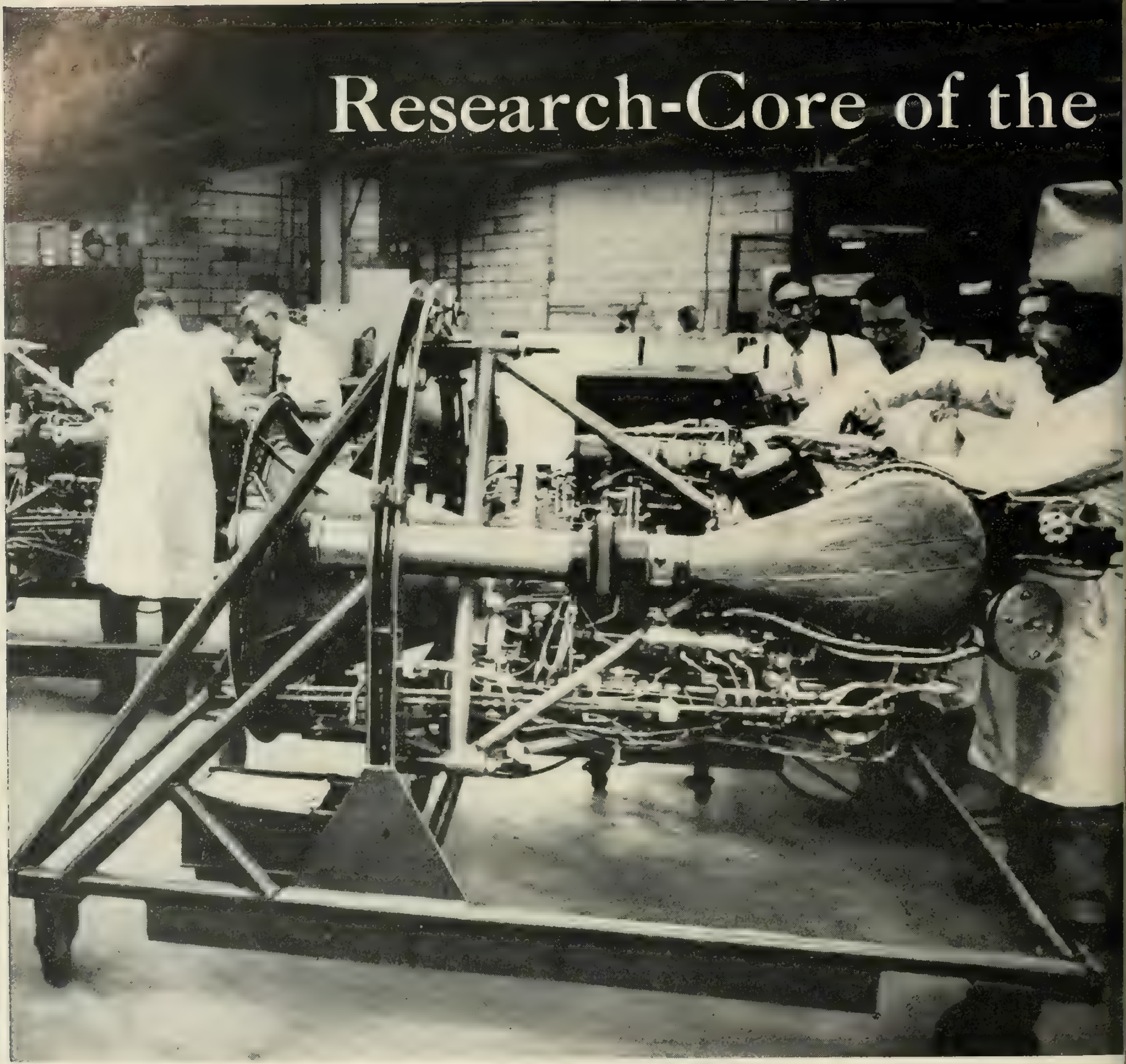
The M/R survey indicated that the four areas which should get the highest priorities are: nuclear rocket research; the development of liquid hydrogen-oxygen second-stage engines; Project *Saturn,* and systems affording a space rendezvous.

Blastoff of a Precious *Atlas*

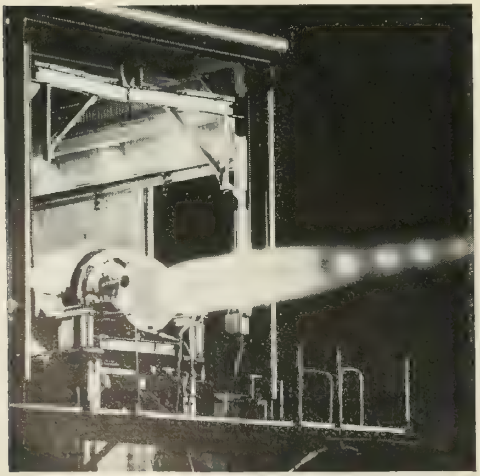


LAUNCHED Nov. 24 from Cape Canaveral, *Atlas 15-D* was eleventh consecutive successful shot. In *Mercury* shoot, *Atlas 10-D* booster failed to separate but overall flight was so successful that NASA cancelled *Big Joe* operation. *Atlas* slated for second *Big Joe* was used on *Able* shot Nov. 26, giving Convair 12 successful and one partial success out of 13 shots since July 21.

Research-Core of the



Most powerful single chamber liquid rocket engine ever built for manned flight—XLR-99—will drive the X-15



Test firing the XLR-99 . . . a major step in research supporting special design and production techniques.

North American Aviation Test Pilot, Scott Crossfield stands by the X-15—America's first manned space craft.

X-15

In designing and building the powerplant for the X-15, Reaction Motors Division of THIOKOL has tamed for human flight one of man's most awesome power sources, the large liquid rocket engine . . . has successfully met many of the greatest challenges ever put to rocket research.

Problem: develop an engine as powerful as an ICBM sustainer, make it controllable and pilot-safe.

This project without precedent demanded completely new concepts in chemistry and metallurgy, in laboratory testing, propellant handling, in use of exotic materials and fabricating techniques.

Basic and applied research in all these and other facets of rocket design and development have resulted in a throttlable powerplant conservatively rated at 50,000 lbs. of thrust (500,000 horsepower). An engine that will respond to pilot's wishes . . . fly him at speeds in excess of 4000 mph, better than 5 times the speed of sound . . . carry him to altitudes of 100 miles, the fringe of outer space . . . and above all bring him safely back to Mother Earth.

THIOKOL is now moving into new phases of rocket propulsion, opening up great career opportunities.

Engineers and scientists will find stimulating work in **astronautical systems analysis, thermodynamics, infra red, electronics of rocket exhaust, electromagneties, solid state physics, high temperature gas dynamics, in many areas of fundamental and applied research.**

Opportunities also exist for chemists—**in propellant analysis, shock wave phenomena, combustion processes, fast reaction kinetics, high vacuum techniques.**

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Circle No. 11 on Subscriber Service Card.

propulsion engineering...

By JAY HOLMES

The huge cost of big boosters . . .

has generated interest in the recoverable booster. And so schemes for recovery by parachute and glider are being discussed. There also is talk about recoverable ramjet boosters that would achieve part of the necessary velocity before a conventional rocket took over.

Obviously, a big saving is involved if the rocket—even a single stage—can be used again. This is likely to become a major consideration by the mid-60's, when we expect to be making frequent shots with multimillion-pound rocket systems such as *Saturn*.

But the savings may prove a mirage . . .

The cost of producing a single vehicle is often only a small part of the overall system cost. Development is usually the biggest item—at least until a few dozen vehicles are used. And so the savings on recovery of vehicles will only scratch at the overall expense.

On the other hand, making a vehicle recoverable adds to its complexity. This requires longer development time, and the cost of development largely depends on time involved. Thus the total cost could increase even though money is saved on recovering vehicles.

Reliability and performance also suffer . . .

when a vehicle is made recoverable. Reliability declines because the vehicle becomes more complex. Performance drops because the recovery system has weight. H. H. Koelle and H. F. Thomae of the Army Ballistic Missile Agency, Huntsville, Ala., have assumed in one calculation that recovery gear for a 1,941,000-lb. loaded booster would weigh about 30,000 lbs.—about 1½% of the takeoff weight.

Nevertheless, Koelle and Thomae concluded in a paper at last month's American Rocket Society convention, recoverable vehicles still may prove less expensive, if the annual firing rate is high. R. P. Buschmann of **Lockheed** reached the same conclusion about vehicles launched 100 times or more. David J. Jones and John O. Tearnen of **Convair Division, General Dynamics**, in the other paper given at the recoverable booster session, confined themselves to a finding that development of a rocket-powered winged booster is feasible.

This is more ammunition . . .

in support of the notion that we should settle on one big rocket and stick with it. Donald Ritchie's survey of Soviet propulsion (pages 17-19, this issue) indicates that the Reds have achieved fantastic reliability primarily by staying with one engine design and using it over and over again.

We could gain in reliability by doing the same—once we develop a booster with enough thrust to do the jobs we want to do in space. At the same time, we could take advantage of the recoverable booster concept. The money saved in recovery may make up for the additional cost of development.

New interest in ramjets . . .

has accompanied the talk about recoverable boosters. More than half of the launch weight of a LOX-RP rocket is oxygen. If air can do even part of the work, we may gain enough in performance to make up for the weight of the recovery gear.

A ramjet booster would take off horizontally. Lockheed's Buschmann suggests a vehicle fueled with hydrogen that burns in oxygen from the air and takes off from a 6000′ to 8000′ runway such as exists on present U.S. Air Force Strategic Air Command bases.

Perhaps the best measure of any such system is what Buschmann calls MOE, or "measure of effectiveness." The units of this parameter are dollars per pound of payload in orbit.

Portable Temperature Chamber Ready

An extremely accurate portable temperature chamber has just been announced by **Delta Design, Inc.** Temperatures can be maintained within ±0.2°F over a range of −100°F to +500°F. This close control is accomplished by a meter-relay in conjunction with a copper-constantin thermocouple.

The new 1060 Series includes a rack mounted model with test volume of 10"x7"x7", two bench models with the same test volume, and a wide drawer model with test volume of 16"x7"x7". Liquid CO_2 automatically cools three of the new chambers, while dry ice (solid CO_2) is used in the fourth chamber. Heating is accomplished by 650-watt electric elements. The unit operates on 117 volts ac and contains a centrifugal blower to assure temperature uniformity throughout the test space, which is fully insulated with low conductivity inorganic fiber.

The liquid CO_2 cooled chambers, in addition to providing extremely fast temperature pull-down, can be programmed with a simple auxiliary timer to alternate between a high and low temperature. All chambers are constructed with stainless steel inner liners and are similar, except for control, to the Delta 6545 Series, which were introduced about a year ago. The new 1060 Series provides the utmost in convenience and accuracy in small temperature chambers.

Circle No. 225 on Subscriber Service Card.

Fluorinated Greases Available in Milled Form

Halocarbon fluorinated greases are now available in milled form for the first time. Milling makes available 100% polychlorotrifluoroethylene greases with conventional grease consistency, ranging from soft to medium, without the addition of any soap or silica thickeners.

A rust inhibitor is also offered for the first time in an inert Halocarbon grease. The Inhibitor, zinc chromate, is available in all series of the new milled form.

These greases, made by **Halocarbon Products Corporation,** are chemically inert, have high thermal stability, good lubricity, high dielectric strength, high density, and non-polar characteristics. Because of their chemical inertness the greases are extensively used as lubricants in missile propellant systems, particularly in those employing liquid oxygen, on launching rails and in liquid oxygen manufacturing equipment. The high density renders the greases useful as flotation media for inertial navigation systems. They are also utilized as coolants for high-power transmitting tubes and transformers.

The use of the Halocarbon greases in missiles prompted the inclusion of the rust inhibitor. The hot days and cold nights at both Cape Canaveral and Vandenberg AFB as well as the extreme cold of liquid oxygen, created severe condensation and rust problems with missiles on the launching pads.

The new milled greases are designated 25-10M and 25-20M. Those containing the rust inhibitor are 25-10MZ and 25-20MZ. They are available in 2 lb. polyethylene bags, for the clean filling of grease guns, in addition to the conventional containers in multiples of one lb.

Circle No. 226 on Subscriber Service Card.

Ultra-High Temperature Laminate Is Produced

A new grade of Dilecto laminated plastic designed for use in missiles and for other applications that require exceptional heat resistance, is announced by **Continental-Diamond Fibre Corp.** Made by impregnating graphite fabric with a heat resistant phenolic resin, the material is now known by the CDF lab designation N-104-84-2. It is still classified as a development item.

Pending further tests and patent investigations, Continental-Diamond Fibre Corp. is making laboratory sample quantities of N-104-84-2 available to companies that have a "DX-A2" Ballistic Missile Program priority. These samples are available in two forms: either laminated 6-in. squares in thicknesses up to ½-in.; or 3-in. dia. cylindrical moldings, made from macerated impregnated fabric, in depths up to 2-in.

In laboratory ablation tests, a 6-in. square by ¼-in. thick sample of this new graphite fabric laminate was exposed to a 5000°F flame. It required more than 10 min. to burn through the sample, giving it a burn-through rate of less than 0.0005-in./sec. Typical burn-through rates for other materials are: 0.0017-in./sec. for phenolic impregnated high silica glass; 0.002 to 0.003-in./sec. for phenolic impregnated felted asbestos and 0.004-in./sec. for phenolic impregnated glass cloth laminates.

Other physical and electrical properties of CDF's new Dilecto phenolic impregnated graphite fabric laminate are shown in Table I.

Circle No. 227 on Subscriber Service Card.

True FM Telemetry Transmitter Available

United ElectroDynamics, is in production on an FM transmitter for use in miniaturized telemetry systems.

Unit combines the best features of both transistors and vacuum tubes. All low-level and frequency-determining stages are transistorized to eliminate incidental FM noise produced by vibrating tube elements. Ruggedized subminiature tubes are used in the output stages. Unit is hermetically sealed for operation at all altitudes, and exceeds Mil specifications for salt spray and other missile environments.

This is a true FM telemetering transmitter, in which the frequency is modulated in accordance with the intelligence transmitted. Designated the TR-10, the unit has been flight-proven in a number of missile programs, and has been tested and certified in the laboratory.

The transmitter accepts inputs from and all other subcarrier oscillators operating in channels which meet MIL-STD-442. Power output is 2.5 watts in the 215-260 mc telemetering band, carrier frequency is crystal stabilized. Size: 4.25"x2.87"x1.53". Weight: less than 17 ounces. United also supplies small, efficient RF amplifiers which amplify the signals to 10 watts.

Circle No. 228 on Subscriber Service Card.

½ Amp. Fast Switching Silicon Diodes Available

A new series of high-current, high speed silicon switching diodes has been announced by **Sperry Semiconductor, Div. of Sperry Rand Co.**

Available in four voltages, the Series 1N690-1N693 diodes effect 0.8 usec switching of ½-ampere pulses and meet other stringent requirements of high current pulse circuits for high speed computer switching, pulse clamping, gating, blocking and diode logic circuits.

Designed for operation form −65°C to +150°C, these diodes also feature high forward conductance (400 ma at 1 volt) and low leakage (50 ua at 150°), and are especially suited for fast switching where current and temperature requirements are considerably in excess of the capabilities of germanium diodes.

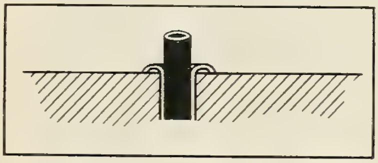
All units feature a maximum recovery time of 0.8 microseconds to return to 10K ohms when switched from a forward current 2 microsecond pulse of 500 ma to a reverse voltage of −50 volts, with a loop impedance of 1K ohm. Typically, these diodes will also switch from a 5 ma forward pulse to −40 volts (−30 volts for 1N690 diode) and recover to 100K ohms in 0.5 usec. (R_L = 2k, C_L = 10 u u f.)

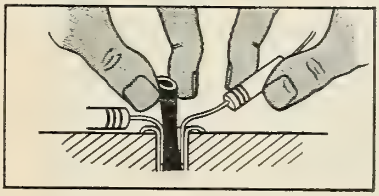
Circle No. 229 on Subscriber Service Card.

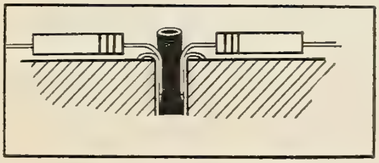
Junction Cell Provides Fast, Solderless Connections

A new method of providing fast, solderless connections between wires and component leads has been developed by engineers at **Plastic Associates.**

The junction cell consists of a gold-plated eyelet and a long-wearing rubber core (upper drawing). When the core is pulled upward, the rubber stretches, allowing wires to be easily slipped inside the eyelet. When released (lower drawing), the rubber core grips the wires or component leads, pressing them firmly against the gold-plated surface and establishing an electrical contact of essentially zero resistance.







Previous methods of providing fast, temporary connections of this type have generally depended on gripping the exposed wires between two opposing metal faces, as in the case of most clips, screw terminals and similar devices. This has caused trouble when the wires are of differing diameter since the larger wire "springs open" the holding device.

The new P/A junction cell solves this problem by gripping the wires between the metal surface of the eyelet and the soft, resilient rubber core. The rubber shapes itself around each wire, no matter what its size or shape. At the same time the rubber provides a firm gripping action that is essentially immune to vibration or shock.

Circle No. 230 on Subscriber Service Card.

Mobile Data Reduction Unit Contained in 40 Ft. Van

A mobile analog-to-digital conversion and data reduction system, contained in a 40′ semi-trailer van, has been developed by **Consolidated Avionics Corp.,** a subsidiary of **Consolidated Diesel Electric Corp.**

The system is capable of accepting up to 215 transducer output signals. It records the data in both analog and digital form and converts the input signals into a form suitable for data processing. A complete system recently delivered to the Army Ballistic Missile Agency is provided with a data storage medium which is compatible with the entry requirements of the IBM 704 computer.

The van is equipped with means for recording analog information on magnetic tape, strip chart graphic recorders and direct writing oscillographs, as well as on meters which provide visual readings.

A bar-graph oscilloscope provides a continuous visual display of 60 channels, enabling personnel to note what is taking place as the analog information is being commutated and converted into digital form at the rate of 600 samples per second. The digital data train is linearized digitally and along with time codes, decimal point location, channel identification and synchronization data, is recorded on magnetic tape, ready for feeding into a computer.

Data values for up to 20 channels may be printed out by direct playback from the digital magnetic tape. This is made possible by inclusion of tape search and editing facilities as well as channel and sample rate selection circuits.

A patch panel permits interconnection of any input signal to one or more recording instruments which may be operated simultaneously. The system may be operated from a control console in the van or from a remote location by removing a section of the console.

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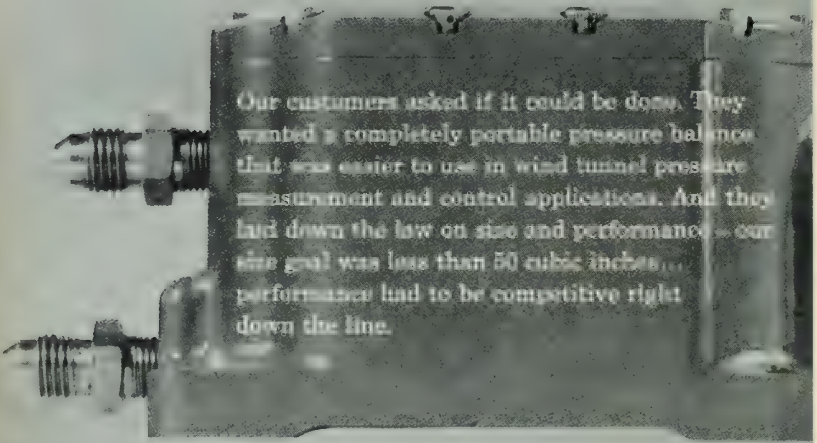

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Transducer Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

Polaris in 1960

Highlights of Final McElroy News Session

by Betty Oswald

WASHINGTON—The **Lockheed** *Polaris* will be operational at sea within a year, according to Defense Secretary Neil H. McElroy.

The retiring Pentagon chief told a farewell news conference last week that test results so far have supported the decision to continue production of the missile and construction of *Polaris*-carrying submarines.

The Navy missile will have initial operational capability on-station by the end of 1960, McElroy said, and after that there will be "one (produced) every four months for as far down the road as we can see."

He said the **Convair** *Atlas* ICBM program was also proceeding well. "We are satisfied that the *Atlas* is a proved weapon and are moving ahead vigorously to deploy it."

McElroy's letter of resignation, effective Dec. 1, was accepted by President Eisenhower, who presented him with the Medal of Freedom "in recognition of his outstanding service to his country and his dedication to his task."

The President immediately named Defense Undersecretary Thomas S. Gates, Jr., to succeed McElroy in the top Pentagon post.

• **Gap confirmed**—Despite his optimistic comments on *Polaris* and *Atlas*, McElroy stated that a missile gap in favor of Russia will exist from 1961 through 1962—and perhaps into 1963.

During this period, he said in answer to questions, "if they build what they could build, and if we build what we intend to build, we think they will have more missile capability."

On the positive side, in addition to *Atlas* and *Polaris*, McElroy cited the **North American** *Hound Dog*, being rapidly developed for use with **Boeing** B-52 bombers. He said *Hound Dog* now has a range of about 500 miles and does not interfere with the bomb-carrying capacity of the B-52.

McElroy did not mention the **Martin** *Titan* ICBM as a major factor in Pentagon planning. When asked to explain this, he merely said "it is intended that *Titan* will continue in the picture."

When he was asked why the U.S. did not buy more missiles to close the admitted gap, McElroy said "the first generation of any new weapon is going to be superseded mighty quickly by a much improved successor." For this reason, he added, the **Boeing** *Minuteman* solid-fueled ICBM is receiving

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optimum funding and *Minutemen* are scheduled to be in place in 1963.

As for anti-missile defense, McElroy noted that, although a decision has been made not to produce the **Western Electric** *Nike-Zeus* AICBM in Fiscal 1961, the budget does include "a very generous support of a research and development program."

He reported substantial progress in development of surveillance drones for use in limited war. He said they go up and fly at a speed of about 200 miles an hour over a wide area, photographing what they see below. Then they come back to their point of origin and are landed by parachute, giving troops a chance to quickly examine the film and select targets.

- **Space report**—On the space front, McElroy conceded that there have been a number of disappointments. He pointed out, however, that the *Discoverer* project had achieved considerable success—even though none of its satellite capsules had yet been recovered.

"Of course," the retiring Cabinet officer said, "we would all like to put something around the moon. This happens to be in our civilian space program now. We would like to get up satellites that have special reconnaissance capabilities and keep them up there, and we would like to put satellites up that have special communications capabilities. I am sure that we will do that, and the programs are rolling along—in my opinion—very well."

Solar Energy Device Can Produce AC or DC Power

WASHINGTON—A new type of solar energy converter which can produce both alternating and direct current at high voltage has been developed by **International Telephone and Telegraph Co.** scientists. The device, shown for the first time at the ARS meeting here, is a ferroelectric converter. It operates by being alternately exposed to sun and shadow—as would occur in a spinning satellite. It could also operate by being heated by a thermonuclear or other heat source.

The converter unit is a ferroelectric ceramic sandwiched between charged plates. When heated, it transfers electrical energy to the plates, increasing the voltage. A single converter element, the size of a dime, can provide outputs of 1000 volts. Outputs of one million volts are theoretically possible with elements connected in series. ITT engineers calculate that the device is potentially able to provide better power output per pound than existing satellite power supplies.

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DataTape Division

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

Big Liquid Hydrogen Plant Proposed

by G. V. E. Thompson

LONDON—**Petrocarbon Developments Ltd.** has estimated the costs of producing liquid hydrogen and are considering erecting a manufacturing plant. In addition to its use as a rocket propellent and in the chemical process industries, liquid hydrogen would be of interest to the electronics industry as a refrigerating medium.

Hydrogen gas would be obtained at an average price of $280 per ton, the possible sources being by electrolysis of water, from petroleum refinery gases, or by refining various hydrocarbons with steam. Hydrogen from refinery gases is purer than that obtained by electrolysis and costs much less (around $150 per ton). However, the supply from this source would be insufficient and would have to be supplemented by reforming ($350 per ton hydrogen).

Petrocarbon have assumed a production rate of 16,000 tons per year and allowed $17 million for capital expenditure. Operating costs have been worked out for a pressure of 8 atmospheres and continuous operation. Power, steam and water, insurance, overheads, chemicals, etc., would cost about $3 million per annum; labour (50 men) and capital depreciation would bring the total to about $5½ million.

This size of plant has been determined by the probable consumption not of the hydrogen, but of the heavy water which could easily be produced by distilling the liquid hydrogen to separate the deuterium it contains, and then burning this. About 11 tons of heavy water could be obtained from 16,000 tons hydrogen (whatever its source) and would have a market value of $28 per pound.

Allowing for the value of the heavy water produced, liquid hydrogen could become available at about $600 per ton. To this sum must be added the expense of maintaining the material in liquid form during storage and transport; the price would still be economic for any firm using appreciable quantities of hydrogen. As a rocket propellant, of course, hydrogen is the most powerful of all fuels.

The proposed plant would use the Cascade process (cooling with a series of liquefied gases boiling at successively lower and lower temperatures) to reduce the temperature of the hydrogen gas to 85°K (—188°C). The coolants used would be liquid ammonia and nitrogen. Further cooling would be obtained by allowing part of the gas to expand through turbines, removing heat from the remainder. Eventually the hydrogen would be liquefied; further cooling would require the use of helium as a refrigerant.

A possible source of trouble is the presence of impurities in the hydrogen gas supplied to the plant. Gases such as nitrogen and methane become solidified and can then erode the equipment and deposit in heat exchangers. Laboratory liquefiers feature activated carbon purifiers for removing the impurities, but these are considered to be too expensive for the large-scale plant. Since the nitrogen concentration tends to rise rapidly on compression, the pressure is being restricted to 8 atmospheres absolute.

Heat economy is important, and the plant will be lagged with expanded plastics. Special attention will be paid to equipment handling gases at temperatures below —200°C. These will be placed within vacuum shields or surrounded with hydrogen itself. This is not the most effective insulant; nitrogen has a thermal conductivity only one-sixth of that of hydrogen, but suffers from the drawback that it deposits solid crystals at the temperatures under consideration. Liquid air is unsuitable because of the potential explosion hazard.

Long runs without maintenance are essential, for similar reasons. Metals suitable for use in the plant include copper, stainless steel and aluminum. The heat exchangers will be built of aluminum, to facilitate movement when they have to be removed for cleaning. After cleaning, it will be necessary to cool the exchangers down to operating temperature before replacement, and this will be done by including them in progressively cooler sections of the hydrogen line.

There are many problems to be solved in the detail design of the plant. These include the selection of the most efficient types of compressor and exchanger, fixing the sizes of the expansion turbines, etc. Allowance must be made for the appreciable shrinkage that will take place when the plant is cooled down to operating temperatures. Pipelines for transporting the liquid may be vacuum-lagged with an additional stream of liquid nitrogen outside the vacuum space.

Progress with *Black Knight*

Development work with the *Black Knight* experimental rocket has been proceeding at Woomera, Australia, and in its fifth firing a height of more than 450 miles was obtained. The velocity reached was more than ten times the speed of sound.

Firing again took place at night the primary object of the trial being to study the effects of re-entry on the nose cone. The rocket is said to have landed within the prescribed area very near the planned impact point; and next morning the Royal Aircraft Establishment recovery team were able to go direct to the landing spot.

Space Law Problems

In his annual lecture in the series "Current Legal Problems," Dr. Bi Cheng of University College, London said that whenever there was a new technological development it was accompanied by demands for a new system of law. There is, he said, no space law other than a projection of existing territorial laws in outer space.

He said it was unnecessary to create a new system of law; existing international law should be adapted to meet the new problems. Some scholars had suggested that laws for outer space should be based on moral principles but it was important to realize that there was no universal moral code on earth. There was no reason to suppose that man's social behaviour in space would be any different from that on earth.

Coating Advance

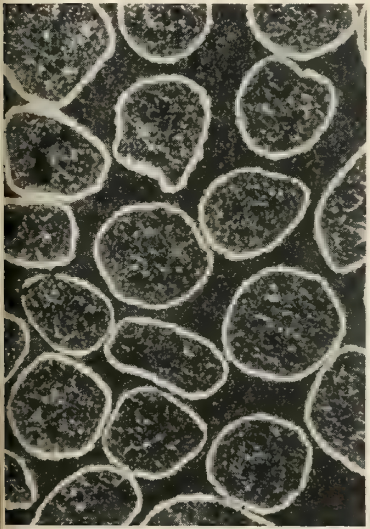
NUMEC Applies Metal To Ceramic Particles

APOLLO, PA.—Micron size particles of ceramics have been successfully coated with thin films of metal by scientists at **Nuclear Materials and Equipment Corp.**

The process is much broader in scope than the coating of ceramics. Arthur Weis, NUMEC's Customer Service and Contracts Manager, explained that the ceramic coatings can be applied to small particles of metals and that metal coated metals are possible.

The ceramic particles can be compressed and shaped or suspended in a plastic medium. The particles can also be applied to a surface by conventional means. Company spokesmen feel that deformation of the substrate in such a case would not be detrimental.

Weis said that the concept permitted the varying of the metal-ceramic concentrations when and where needed vith comparative ease.



CROSS SECTION OF NUMEC'S nickle-coated uranium oxide in plastic medium (100X). Note uniformity of the film.

The process enhances the high-emperature applications of ceramics nd cermets by combining the properies of metals with the characteristics f the refractory substances.

NUMEC is primarily involved in roduction of enriched uranium fuels or reactors and is engaged in research nd development projects relating to igh-temperature materials. The comany recently fabricated a small rocket ozzle from an alloy of metals and eramics which withstood 2500°C for ixty seconds in a stream of hot gas.

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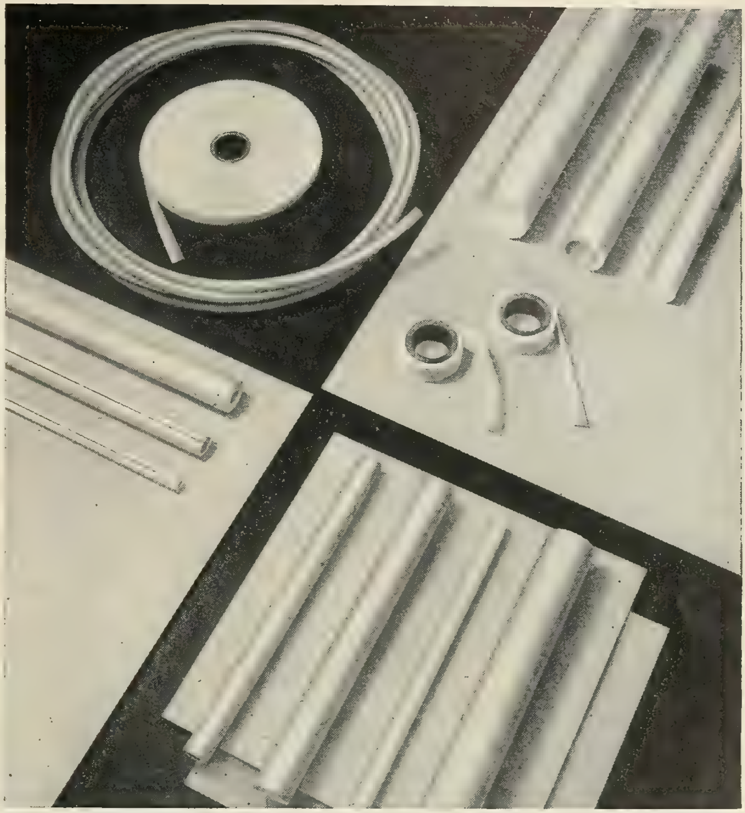

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Energy Conversion

(continued from page 24)

operation a coordinated and concentrated effort in energy conversion that has already produced significant results in thermoelectrics. Most of the Navy's money to date has come from ARPA, but with the new organizational setup it will probably be necessary to fund most of its projects in-house.

The Office of Naval Research power branch is responsible for coordinating the Navy effort. Its primary mission is to support basic research programs, mainly in materials. Current ONR funding amounts to about $600,000, spent on contracts to various universities, industrial and research organizations. The ONR program was started modestly in 1955 with basic research in fuel cells and thermoelectrics funded for $150,000.

Naval Research Lab works under ONR and acts primarily as a contractor to other Navy agencies as well as to other services. It supports material research and furnishes measurement facilities. The Lab's energy conversion branch works primarily in applied research and also concentrates on devices in several areas.

The big Navy effort is presently centered in the Bureau of Ships. Current funding totals around $3-3.5 million, with the bulk of this going to materials development. BuShips has concentrated in thermoelectrics and has seen considerable success in this program. They also have done some work in fuel cells. The Navy is primarily concerned in the program as a facet of work on the ultimate submarine. BuShips funds come from in-house R&D money as well as from other agencies such as ARPA and NASA.

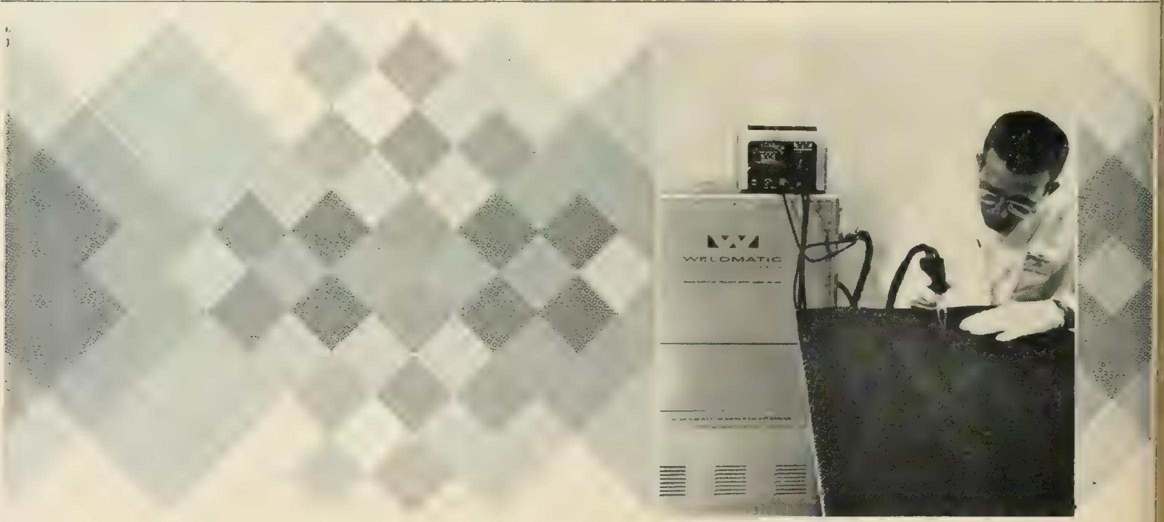
Navy's Bureau of Aeronautics (or BuWeap) is just getting into the business. It is conducting investigations into the advisability of doing research in some of these areas and supporting work, but to date no money has been allocated. Interest is primarily in thermoelectric systems powered from propulsion heat and in heat storage devices. Some interest has been expressed in fuel cells.

- **Army**—Army's assignment in the interservice group has been primarily in fuel cell development and in solar cells. It contracts through several different agencies: Signal Corps, DOFL, Transportation Corps, European Research Office, Corps of Engineers, BuAer, ONR and WADC. Completed and current contracts run better than $2 million. Support for fuel cell research projects is set at an annual rate of around $500,000.

The Signal Corps has sponsored annual power sources research and development conferences since 1947. This conference first reported work on fuel cells in 1955. The 13th annual conference this year covered thermoenergy conversion, nuclear energy sources, solar energy, fuel cells, and batteries.

Army feeling is that conventional power sources such as primary batteries and engine generators no longer meet the needs of a modern Army. By 1965 they estimate that most of present conversion sources will be obsolete.

Although indications are, as pointed out before, that there may be much lost motion in the military's energy conversion program, there appears to be hope that much will be done in the next few years. There is certain to be increasing need for exotic power sources for missiles, in space, and for underwater applications. Parallel with the developments coming out of military programs will quite likely come developments for the commercial field. One scientist working in this area has stated that he would not be surprised to see within five years automobiles operated on fuel cells.



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• **Washington**—NASA announced it would launch next spring a 100-foot-diameter inflatable aluminum-covered sphere into a 1000-mile-altitude earth orbit. Object is to test feasibility of a passive reflector communications systems on a global basis. Inclination will be about 50° to the equator and orbital period will be 120 minutes. Launch will be by *Delta* vehicle with three shots planned under code name of *Echo*.

• **St. Louis—McDonnell Aircraft** received a contract amendment to build six additional space capsules for Project *Mercury*. The new order brings the number of capsules ordered by NASA to 20.

• **Cape Canaveral**—*Thor* fired Dec. 1 carried movie camera to take first high-altitude color pictures of the earth. Capsule landed slightly short of the intended impact area and Air Force called off search 90 minutes after firing.

• **Washington**—Bureau of Naval Weapons—a merger of Bureau of Ordnance and Bureau of Aeronautics—went into operation Dec. 1, several months ahead of schedule. New bureau will get about 40% of Navy's budget and 70% of its R&D funds, along with some 204,000 military and civilian personnel.

• **Washington**—Defense Department said two high-powered radar units—one a modified **RCA** unit originally designed for BMEWS system, the other a **Raytheon** unit—will be used to detect and identify incoming missile warheads on an ARPA installation at Rol Namur Island in the Pacific. Experiments, using unarmed IRBM-type missiles launched from Johnston Island, goes under the title of Project *Defender*.

• **Washington**—NASA asked Congress for broad leeway to grant patents to industry on inventions developed through government-financed research. Aerospace Industries Association told the Mitchell Subcommittee of the House Science and Astronautics Committee present patent provisions in the Space Act deny NASA freedom to promote space technology as rapidly and efficiently as possible.

• **Paris**—Scientist Anatoly Blagonravov of the Soviet Academy of Sciences said Russia soon might build 60-passenger rockets and that present Soviet rockets are powerful enough for such craft.

• **Canberra**—The Australian Government announced it has decided to order the **Bristol Siddeley** Thor ramjet-powered *Bloodhound* surface-to-air guided missile. Sweden has also chosen *Bloodhound* for anti-aircraft defense.

• **Los Angeles**—NASA—although it will have about 20,000 people—will only be able to handle about 15% of its work in-house and industry will get the remainder. This estimate was made by Abe Silverstein, Director of Space Flight Development for NASA, at a meeting of the Institute of Aeronautical Sciences here. Silverstein told M/R no decision has been made on whether to use *Titan* or *Titan-C* for second stage of *Saturn*.

• **Ogden, Utah**—Air Force said production plant for first stage *Minuteman* motor would be built on **Thiokol** facilities near Brigham City. *Minuteman* assembly and repair facilities wil be built at Ogden, with **Boeing** operating this unit. A former ordnance plant adjacent to Hill AFB will be used for assembly of the missile.

• **Cape Canaveral—Tool Research and Engineering Co.** of Beverly Hills will build for **Kaiser Steel** a six-story-high, completely mobile launcher for 50-foot *Pershing* missile. TREC has contract for one unit, with follow-on contract possible.

• **New York—International Nickel Co.** announced development of a new family of very-high-strength steels containing about 25% nickel, which have yield strengths from 250,000 to 290,000 psi. Nickel content varies from 20 to 30% with smaller additions of titanium and aluminum.

• **Golden, Colo.—Coors Porcelain Co.** opened new facility for production of dense ceramic parts from beryllium oxide compositions.

• **New York—Schwarzkopf Development Corp.** announced new process for producing tungsten ingots with weights up to 200 lbs. Tungsten cylinders of about 8″ diameter and 8″ height are formed from powder in large-capacity presses. Blocks are sintered and forged at high temperature.

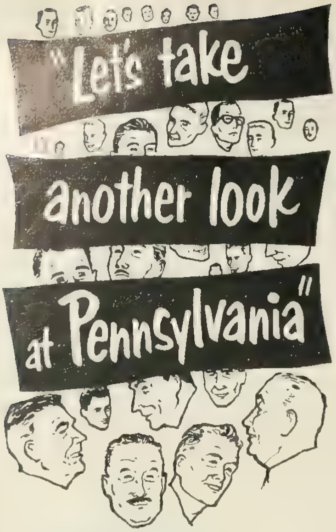
• **Dallas-Texas Instruments, Inc.** said the electronics industry's first all-solid-state, 400-MC beacon transponder, carried in a *Thor-Able* Sept. 17, responded from 1300 miles in space to an MIT Lincoln Laboratories Millstone radar which tracked the missile from horizon to horizon during 14 minutes of flight. Unit is capable of 40 hours continuous operation, weighs 6.3 pounds and occupies 0.058 cubic feet.

• **New York**—An **International Telephone and Telegraph Corp.** multiplier phototube used in a balloon ascent 15 miles above the earth on Nov. 28, converted into electrical signals the light reflected off Venus' impenetrable atmosphere. It amplified the signals two million times, producing data which indicated presence of water vapor.

• **Chicago—International Harvester Co.** offered to purchase **Solar Aircraft Co.** by an exchange of stock. Proposal calls for Harvester to offer Solar stockholders one common share of Harvester for each 2¾ common shares of Solar.

• **Washington**—Mergers, expansions, acquisitions: **Leach Corp.** purchased the **Electronics Division** of **Pendar, Inc.** . . . **Chromally Corp.,** White Plains, N.Y., acquired **Sintercast Corp. of America,** Yonkers, N.Y., producer of special tool materials, boron, tungsten and titanium compounds and nuclear reactor metals . . . **General Magnaplate Corp.,** Belleville, N.J., acquired **Eastern Testing Laboratories,** Corona, Long Island . . . **Thompson-Ramo-Wooldridge Products Co.** leased additional space in Beverly Hills which represents a 20% increase in the facility . . . **Douglas Aircraft Co.** announced establishment of an advanced research organization in Santa Monica . . . **General Dynamics Corp.** and **Material Service Corp.** of Chicago signed an agreement calling for merger of the latter into Dynamics as the Material Service Division, subject to approval by share owners.

• **Washington**—Late contract awards: Additional $5,250,000 order to **Westinghouse Electric Corp.** for initial work on launching systems for equipping four fleet ballistic missile submarines . . . A $270,000 contract to **Sylvania Research Laboratories** from **Aerojet-General Corp.** for development of refractory metals, alloys and compounds for solid fuel motors.



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missile business . . .

By WILLIAM E. HOWARD

It will come as heartening news to some that the Air Force now is showing signs—after being designated the nation's military "space force"—of preparing to make a stiff fight next year for a realistic space program. And not merely as some sort of glorified handmaiden to NASA.

On the contrary—the AF may be battling NASA . . .

for top role when various congressional committees begin digging into such questions as why the U.S. is behind Russia and whether Soviet achievements have any bearing on the security of the nation.

Quite clearly, the AF is ready to challenge the whole Eisenhower doctrine that space belongs solely to "science." The first official expression opposing policy came a few days ago from Lt. Gen. Bernard A. Schriever, commander of ARDC, in a speech to the Aero Club of Washington. (Schriever, incidentally, admitted frankly that the speech had been well-laundered in advance by security review.)

Said Schriever: "We cannot afford to concentrate solely

on scientific explorations in space, and ignore its vast extension of the air as a theater of military operations. Our adversaries are not bound by either legal restrictions or moral law, limiting their exploration of space to peaceful scientific objectives.

"It is commonly accepted that their effort is a total one . . . to control any territory within their reach. For this reason, we cannot afford to set our military services apart from the scientific and industrial community, confining our use of the techniques and facilities which we have developed solely to the refinement of existing weapon systems."

This is a clear-cut statement of the issue—pure science vs. military use of space—that Congress and the Nation must come to grips with, if future programs are to have any perspective and objective. It is the hope of many in industry that this issue will be weighed against the broad perspective of history—which shows a consistent record of military technology moving ahead with almost every scientific advance. This may seem an obvious fact, but it appears to escape many leaders when they start peering into space.

One for the calendar . . .

After Jan. 1, four of **General Precision Equipment Corp.'s** seven divisions—**Kearfott, Librascope, Link Aviation** and **General Precision Laboratory**—will all be consolidated into one division. It will be called **General Precision Inc.**

One to watch . . .

The newly formed **National Electronics Facilities Organization Inc.** is an experiment in industrial teamplay. **Servo Corp., General Transistor Corp., Blount Brothers, Specialty Electronics Development Corp., Nytronics Group,** and **Technical Research Group** have united into a "super corporation"—NEFO—to bid as a prime on military contracts. Each company will retain its separate corporate identity and, as such, will still be competing with its teammates for subcontracts.

The group as a whole has a total of 4000 employes and assets amounting to some $25 million. And the blessing of Wendell B. Barnes, retiring head of the Small Business Administration, who said:

"I shall watch your progress with interest and trust that your example will be followed by many other such combinations."

people

Dr. Vergil L. Saine, formerly assistant director, has been appointed director of solid propellant operations at the Ordill plant of Olin Mathieson Chemical Corp.

SAINE

Dr. Saine joined the firm in 1951 and has held various positions in the technical and production departments relative to development and manufacture of rocket propellants, cannon propellants and supporting raw materials. He previously worked with Hercules Powder Co. and Carbide and Carbon Chemical Corp. in atomic energy research.

Lockheed Missiles and Space Division has announced the appointment of **James S. Farrior,** nationally-known missile guidance expert, as *Polaris* missile system guidance manager. He replaces **A. F. Blight,** who assumes the position of *Polaris* internal systems manager.

FARRIOR

Farrior was previously with the Army Ballistic Missile Agency, Redstone Arsenal, where from 1951 to this year he was chief of the navigation branch responsible for the *Redstone, Jupiter* and *Pershing* missiles.

R. B. Parkhurst, who has been vice president and manager of the Products Group of Hughes Aircraft Co., has returned to his position of vice president-manufacturing on the corporate staff, and **I. F. Richardson,** former director of programming, Airborne Systems Group, has been named manager of the Products Group. Before joining Hughes, Richardson was general manager of the Kansas City division of Bendix Aviation Corp.

Jack Parkin has been assigned corporate project responsibility for the *USD-5* surveillance drone being developed by the Fairchild Engine & Airplane Corp. for the U.S. Army.

Parkin was previously with Bell Aircraft where he was assistant project manager of the *Rascal* program, director of engineering of the Bell Avionics effort and more recently manager of the Bell Task Force, established to integrate the *Rascal* into Strategic Air Command operations.

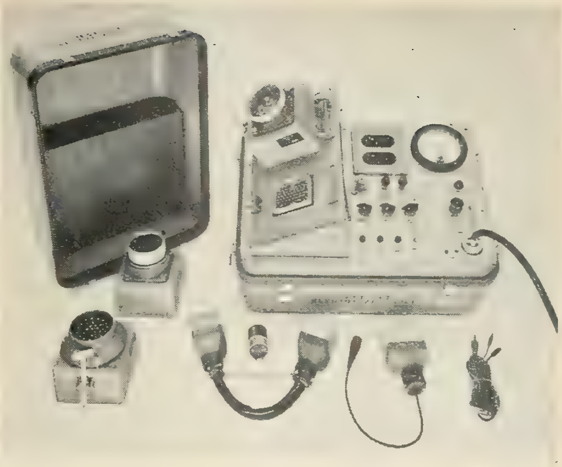
He succeeds **Grayson Merrill,** who has been operating in the dual capacity of general manager of the Astrionics Division and corporate *USD-5* manager. Merrill will now devote his full effort to general manager-Astrionics.

Due to the recent expansion of the company, Feedback Controls, Inc., manufacturers of electronic components and systems for control and computation, has transferred **Rear Adm. William S. Harris** (Ret.) to the home office in Natick, Mass., to assume the position of vice president-administration. **Fred Thompson** was also promoted to Eastern Division Sales Manager.

William K. Squires has been named operations research manager for Lockheed's Electronics and Avionics Division. He was formerly associated with the Rand Corp., where he directed studies in nuclear weapons effects, communications and radar. Prior to that he was president of Telemeter Magnetics, Inc.

Edward L. Swainson has been appointed technical assistant to the president of the Military Products Division of American-Standard. He will be responsible for technical liaison between departments of the division and will have a major responsibility for its long-range technical planning.

Avco Corp., Nashville Division has announced the appointments of **Bernard Clark** as general manager-operations and **Eugene B. Husselman** as manager of the materials department.



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soviet affairs

by M/R Staff from Translations

Crimean Telescope Among World's Largest

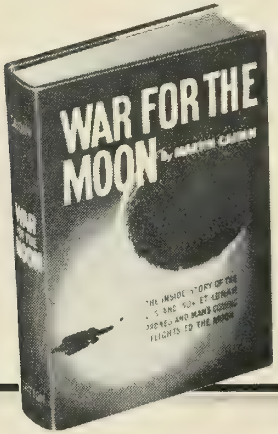
One of the largest telescopes in the world, and the Soviet's biggest, will be guided almost completely by the body upon which it is focused.

Designed to stand in the Crimean Astrophysical Observatory of the Academy of Sciences, USSR, it will be used to track artificial earth satellites and cosmic rockets and study nonstationary stars, the stucture of the moon, planets and distant galaxies.

The 2600mm-diametered mirror's sighting, focusing and correction for refraction systems will be automatized, employing the light flowing from the body it will track. In this type of guidance system, as described in *Trud* (Nov. 4, 1959) the light rays strike a special receiver and are transformed into alternating electrical signals. These signals, amplified a million times, set the control system into motion and introduce corrections in the position of the telescope tube.

In addition, a group of Soviet scientists has worked out an automatic device to rotate the dome and shutter simultaneously with the telescope to create an almost entirely automatic system. It is now developing a program of control whereby the astronomer can issue the necessary commands beforehand and the instrument itself will aim at the desired object, follow and photograph it, then turn to other objects.

Photographs taken with this system are expected to be of quality superior to those from manually operated instruments, since controls will eliminate defects and elongation caused by the earth's rotation and duration of exposure.



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New Forming Process?

A new metal forming process producing shapes directly from the molten state reputedly is being developed by a Russian metallurgist.

A. V. Stepanov in *Vestnik mashinostroyeniya* (No. 11, 1959) describes his process as utilizing capillary forces, where liquid metal rises within an opening in the die, floating freely on the top of the metal bath. A "graft," or piece, of the same metal with the same shape as the opening in the die, is introduced into the die opening until it reaches the liquid metal and welds to it. It is then withdrawn at a rate corresponding to the rate of solidification, which can be controlled by a proper cooling system.

Stepanov claims to have obtained wires, strips .5-2.00 mm thick and up to 120mm wide, round tubing 5, 60 and 100mm in diameter, elliptical spirally wound tubing, and tubular panels up to 120mm wide, some with no additional surface machining.

Borane for Cooling

The Soviets claim the discovery of a new "exotic" fuel "borane," a mixture of hydrocarbon and a boron compound. Considered three times as powerful as alcohol fuels, it is used for cooling purposes instead of liquid oxygen.

Success in the USSR's space program is attributed also to simplification. According to West German magazine *Quick* (No. 44, 1959), the Soviets still use the principle of the *V-2*—a regular rudder made from graphite moving in the jet stream of the rocket. Auxiliary rockets are used only for braking and acceleration purposes. Black and white paint is used to protect the instruments carried by the rockets.

Vegetation on Mars?

The "Grand Old Man" of Russian astronomy, Prof. G. A. Tikhov, maintains that he has offered indisputable proof of the existence of cholorophyll —and hence vegetation—on Mars.

Interviewed by a correspondent for the West German magazine *Quick*, (No. 44, 1959) he disclosed extensive studies on the subject. His feeling is that manned space flights are necessary to find new inhabitable areas to alleviate earth's crowded conditions.

When would man land on the moon? "In two to three years," says Prof. Tikhov.

Stationary Orbits

The Russians have their own program to put radio and television relay systems into space.

A paper by Soviet scientist Prof. S. Katayev, reported in *Isvestiya*, (Nov. 6, 1959) tells of a Soviet plan to put satellites into stationary 22,000-mile-high orbits. Katayev states that a radio relay system in the satellite would open all of the USSR to TV.

Other satellites not carrying relay systems will be used to reflect radio waves transmitted from ground TV stations back to earth. The waves would be received by large antennas, amplified, converted and transmitted to ordinary TV receivers.

Soviet scientists are also discussing, according to Katayev, the possibility of predicting the future development of the earth by similar rockets carrying photographic equipment. By photographing Mars, which is estimated to be millions of years older than earth, and on which at one time conditions may have been similar to this planet's, the Soviet astronomers expect to see what physical changes may be in store for it. The Soviets also expect to photograph celestial bodies with their space telescopes in the near future.

Dr. Albert Parry, professor of Russian at Colgate University, has long contributed a monthly column on Soviet Affairs to M/R. Because of the increasing interest in things Russian, we now plan to supplement this coverage with more frequent material emanating from the USSR, translated by official sources in this country, and compiled by the M/R editors.

ASW Problem Answered

To the Editor:

In your editorial of August 10 you voiced the fear that the Navy Department was not properly organized to handle the anti-submarine warfare problem. I wrote to Senator Eugene J. McCarthy (D-Minn.) and included a copy of your editorial.

He obtained a gracious and informative response from Rear Adm. H. A. Yeager. A copy of this letter was sent to me by Senator McCarthy and certainly clarifies in my mind any questions which might have been raised regarding Navy organization to cope with the ASW problem.

Charles Eumurian
1016 W. County Road B2
St. Paul 13, Minn.

(We have obtained permission from both Senator McCarthy and Admiral Yeager to print the Admiral's response to Mr. Eumurian's request. It follows:)

"My dear Senator McCarthy:

"The criticism contained in the article of the organization of the Navy Department for dealing with antisubmarine warfare measures is not without foundation, but as with many such articles, it is out of date. Significant improvements have been made and industry is now eminently satisfied with the situation. Salient among the improvements which have been made was the establishment in January 1958 of the Antisubmarine Readiness Executive, a special assistant to the Chief of Naval Operations charged with the supervision of all matters pertaining to ASW readiness.

"Additional improvements include the establishment in July 1959 of the Deputy Chief of Naval Operations for Development, whose supporting staff includes a section designed exclusively for handling ASW projects. Reorganizations have taken place within the technical bureaus and in the Office of Naval Research to streamline procedures for handling ASW matters.

"Instructions have been issued to facilitate access by properly cleared members of industry to classified information necessary for progress in the development of improved ASW methods. Additional instructions to facilitate the submission and processing of proposals relating to antisubmarine warfare are being developed, and are expected to be issued shortly.

"Reorganization and streamlined procedures will not solve the Navy's antisubmarine warfare problem. What is needed is an extensive program of basic research in oceanography and other related fields, and the provision of financial support as required to translate sound ideas into useable ASW systems.

"Progress is being made in these research efforts, under Navy contracts, and in projects being pursued by industrial concerns, several of which are expected to result in government contracts. Thus far, however, no feasible, inexpensive, overall solution to the threat posed by the existence of the 450-unit Soviet submarine fleet has been evolved.

In the absence of such a solution, the Navy is improving its current ASW capabilities by intensive training and by the introduction of promising new methods as rapidly as their value can be proven by rigorous test and evaluation procedures. We believe that only through such deliberate and carefully conducted procedures can the expenditure of public funds on the increasingly expensive equipments required in antisubmarine warfare be justified.

/s/ H. A. YEAGER
Rear Admiral, U.S. Navy"

Avco's Acquisition

To the Editor:

The August 31st issue of MISSILES AND ROCKETS carries a story on page 41 entitled "The Growth of **Avco**" in which it states that Bendix was acquired by Avco. It is obvious to us that it was **Bendix Home Appliance,** but to the average reader this could mean **Bendix Aviation Corp.**

Even at this late date I would appreciate it if you could correct any impression that Avco had acquired the Bendix Aviation Corp. Obviously this is not true and the "Bendix" to which the story referred was the Bendix Home Appliance Corp. which, I believe, Avco later sold to **Philco**. There is no connection between this organization and our own but the similarity in names has always caused some confusion.

W. A. Mara, Director
Advertising & Public Relations
Bendix Aviation Corporation

The Spaceless Military

To the Editor:

There have been a number of public statements recently by President Eisenhower, Defense Secretary McElroy, Dr. Herbert York and other high government officials justifying the reduction in funds for the *Saturn* 1.5-million-pound booster rocket program and its transfer to NASA on the basis that it is of use only in our civilian space research program. It is explained that our military programs do not require rocket engines of this large size and that the lower-thrust ICBM engine programs are being funded with "all the money they can absorb efficiently."

At the same time, it is well known throughout the missile/space industry, and published in the technical journals, that any program for a manned space vehicle with capabilities beyond the low orbits to be achieved in the *Mercury* program will require much larger booster engines.

This amounts to a clear and public admission that the U.S. Air Force has not recognized the military value of manned space vehicles to the point of establishing a military requirement document which would lead to funding of a large booster engine.

It seems incredible that our military people continue to make mistakes of this magnitude in the planning of new weapons systems . . .

W. J. Billerbeck
Engineer
Silver Spring, Md.

The decision that the U.S. military had no mission in space was made by the Administration. The Services, most particularly the Air Force, nonconcur rather vehemently.—Ed.

ASTROLOG Welcomed

To the Editor:

I have noted with interest and appreciation the very handy summary of missiles and rockets which appeared in your Sept. 7 and Nov. 9 issues.

Without a reference guide such as your ASTROLOG it is an impossible job to keep track of the many types of rockets and missiles which the armed services are now using or testing. Those of us in the information business welcome your very helpful compilation with enthusiasm.

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—contracts—

NASA

$400,000—**Telemeter Magnetics, Inc.**, Los Angeles, for development and manufacture of airborne digital programmers and ground-based check-out systems for Project *Vega*. Subcontract from **Jet Propulsion Laboratory**.

$38,037—**Coopman Electric Co.**, San Francisco, for thermocouple and miscellaneous wiring for 3.5-ft. hypersonic wind tunnel.

MISCELLANEOUS

$270,000—**Sylvania Research Laboratories**, Division of Sylvania Electric Products, Inc., for research and development work on high-temperature materials for use in solid-fuel rocket engines.

NAVY

$5,250,000—**Westinghouse Electric Corp.**, for continued work on *Polaris* missile launching systems.

$300,000—**Packard Bell Electronics Corp.**, for the production of radar test sets.

$73,338—**The Dynamics Research Corporation**, Stoneham, Mass., for continued investigations of the *Polaris* submarine inertial navigation system.

$65,447—**American Machine & Foundry Co.**, Chicago, for studying experimental model of an interval environmental simulator for space crew. Project C-41111.

$28,020—**Ampex Corp.**, Los Angeles, for magnetic tape recorder system and components.

$25,345—**Ampex Corp.**, Los Angeles, for magnetic tape recorder and reducing components.

AIR FORCE

Convair (Astronautics) Division of General Dynamics Corp., has received a contract for the design of a major space vehicle launch complex at the Atlantic Missile Range, Cape Canaveral, Fla. Amount not disclosed.

$9,384,733—**Stromberg-Carlson**, div. of **General Dynamics Corp.**, for changes in design of a complex reconnaissance system. Total cost of project to date, $26,907,062.

$202,980—**Potter Instrument Co.**, Plainview, N.Y., for punched tape reading equipment to be used in the *Minuteman* ICBM program. Subcontract from **Autonetics Division, North American Aviation Co.**

$118,000—**General Electric Co., Heavy Military Electronics Dept.**, for study involving launch control system communication techniques for the *Minuteman* ICBM. Subcontract from **Boeing Airplane Co.**

$85,711—**The Martin Co.**, Orlando, for *Bullpup* trainers, ground pilot *GAM-83*.

$79,500—**Boeing Airplane Co., Pilotless Aircraft Div.**, Seattle, for reproducible copy and negatives applicable to *IM99A* missiles (Two contracts).

$74,975—**Cornell Aeronautical Laboratory, Inc.**, Buffalo, N.Y., for research directed toward the investigation of auroral and lunar reflected signals.

$34,160—**Stanford Research Institute**, Menlo Park, Calif., for research on application of electron beam machining techniques to semiconductors.

ARMY

$4,721,786—**Del E. Webb Construction Co.**, Los Angeles, for rocket engine test stand 1B at Edwards AFB.

$700,000—**Northeastern Engineering, Inc.**, Manchester, N.H., for 600 frequency meters.

$426,600—**C. H. Leavell & Co.**, El Paso, Tex., for *Nike-Zeus* facilities, battery control building, White Sands Missile Range, N.M.

$255,357—**Western Electric Co., Inc.**, N.Y.C., for reconditioning secondary items for *Nike* guidance system.

$226,905—**Microwave Electronic Tube Co., Inc.**, Salem, Mass., for electron tubes.

$179,382—**Proctor Engineering Co.**, Tulsa, Okla., for construction of nose cone facility at Forbes AFB, Topeka, Kan.

$129,847—**North American Aviation, Inc.**, Downey, Calif., for study of space vehicle vulnerability.

$100,000—**Melpar, Inc.**, Falls Church, Va., for flight test data processor.

$80,900—**The Martin Co.**, Orlando, for *Lacrosse* missile and related equipment.

$80,333—**Western Electric Co., Inc.**, N.Y.C., for *Nike* spare parts and components (Two contracts).

$49,000—**Ohio State University Research Foundation**, Columbus, for additional research work on satellite ionization phenomena and observation.

$33,250—**Research Triangle Institute**, Durham, N.C., for basic research, design and analysis of experiments to determine effects of factors on response variables.

$30,380—**H. B. Zachry Co.**, San Antonio, Tex., for *Nike-Zeus* facilities, landing strip and AIL facilities, White Sands Missile Range.

$30,000—**California Institute of Technology**, Pasadena, for hypersonic research.

$29,680—**Firestone Tire and Rubber Co.**, Los Angeles, for modification of guided missile.

$28,182—**Douglas Aircraft Co., Inc.**, Santa Monica, for launching area items.

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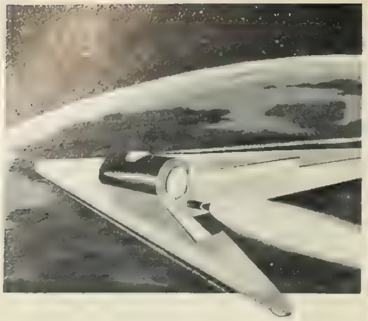

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—reviews

QUANTITATIVE MOLECULAR SPECTROSCOPY AND GAS EMISSIVITIES, S. S. Penner, California Institute of Technology. Addison-Wesley Publishing Company. 571 pp. $15.

Written as a text book, the volume covers selected topics in quantitative applied spectroscopy.

The theoretical and experimental studies which are considered in detail are representative of the types of research problems encountered in connection with the development of modern propulsion devices.

The book is aimed towards students in applied science as an introduction to the literature on a class of radiation problems which largely fall into the temperature range intermediate between that of interest to the molecular spectroscopist and the astrophysicist.

CHEMISTRY OF NUCLEAR POWER, J. K. Dawson, and G. Long, A.R.I.C. Philosophical Library Inc., 208 pp. $10.00.

The authors, both of whom are engaged on research work at the Chemistry Division, Harwell, England, present a highly authoritative and informative account of the part of the chemist in the development of nuclear power.

From the raw materials through the various separating processes and reactors to the disposal methods in current use the subject matter is presented as a broad picture of established practice and present lines of thought. The chemical problems of the future are treated in closing in a manner digestible to those with scientific training but lacking specialized knowledge in nuclear technology.

RANDOM VIBRATION, Edited by Stephen H. Crandall, Massachusetts Institute of Technology. John Wiley and Sons Inc. and Massachusetts Institute of Technology, 411 pp. $8.50.

The material in this book is specifically addressed to engineers who are already familiar with the classical problem of mechanical vibration. The new concepts required to extend ordinary vibration theory into the field of random vibration are described and a broad picture is given of the current state of the art of designing and testing equipment which must withstand random vibration.

The recent development of high power rocket engines has introduced a new aspect to the problem of mechanical vibration. These propulsion units generate noise and vibrational energy in a stochastic manner over a wide band of frequencies. The resulting random vibration often constitutes a severe environment with respect to fatigue of airframe panels and with respect to reliability of airborne electronic equipment.

The book is divided into two parts. The first six chapters treat basic concepts and background material. The final sections deal directly with the problems of design and testing.

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Applicants for these positions should have a BSEE, BSME or BS in Physics with emphasis having been placed on electronics. Must be able to work well with other people and analytical ability to reach sound solutions to problems. It is desirable to have some Fire Control and/or Radar experience and also be familiar with digital techniques, printed boards and transistorized circuits.

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Mr. R. G. O'Brien Div. 73-WW
ORDNANCE DEPARTMENT
of the Defense Electronics Division

GENERAL ELECTRIC

100 Plastics Ave., Pittsfield, Mass.

Public Awakens to Space Loss

For the past year or more we have believed, and frequently reiterated on this page, that as the prospects of a hot war become less threatening, the aspects of the cold war become more deadly. That the cold war is really the more terrifying because it is being waged for the minds of men. That the physical capture and control of a man leaves room for rebellion and escape, whereas the capture and control of his mind leaves a man nothing.

This battle for men's minds is being carried on in a number of ways, but its best exemplification is in the race for space. As was pointed out in an article in this magazine last week, a race does not necessarily need two participants; all it requires is one runner, a prize and an interested audience.

At the moment probably much of the world, which is the highly interested audience, would say there is only one contestant—Russia. Others might hold differently and give the United States second place—since there isn't a possible third participant and there isn't likely to be one soon.

As the winner of the race so far, Russia is picking up all the prizes—the accolades of the world, the solidified appreciation of its own people and probably potential billions of dollars on the world market—through its demonstration of scientific and technical superiority.

Noting some of these things in a recent paper laid before the American Rocket Society meeting in Washington, Dr. William H. Pickering, Director of NASA's Jet Propulsion Laboratory, declared that we must either pursue our space developments actively and successfully or declare ourselves completely out of the space race. He laid down three ground rules for successful competition:

1. The U.S. public must understand the importance of our space program.
2. We must establish national objectives clearly to set up a mainstream of dramatic achievement as well as a broad base of exploration and exploitation.
3. We must establish the management and the funds to properly support, on a long-term basis, our real national objectives.

Note that Dr. Pickering has made public understanding first on his list. From all indications the understanding must be imparted on a very high level.

There has been no indication from the Administration and very little from our space agencies that they feel any sense of urgency or apprehension—or even embarrassment over our loss of world prestige. We have business as usual, bigger automobiles and a balanced budget.

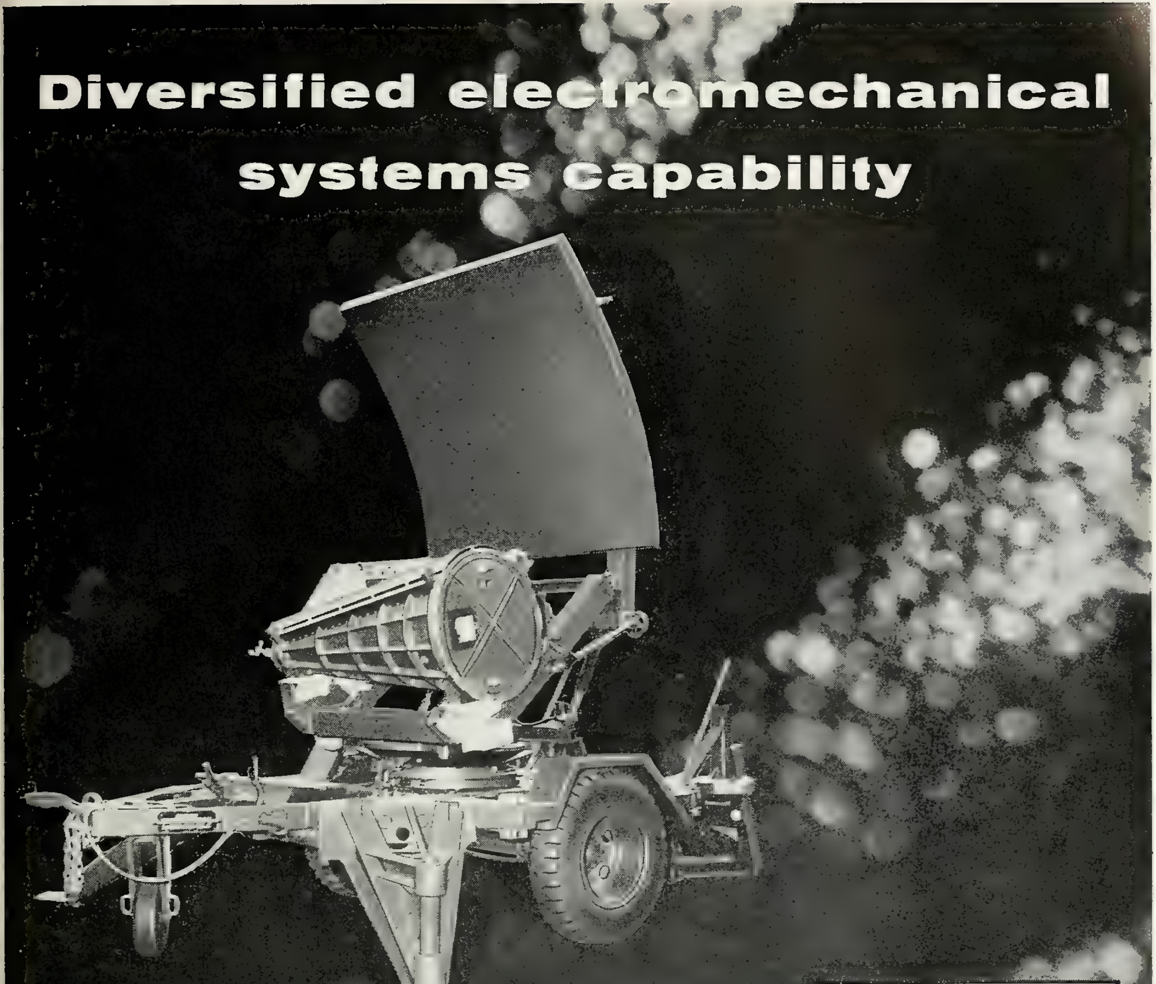
Does the American public enjoy having the Russians rub our noses in our failures? Does it enjoy having foremost Soviet Scientist Sedov look at the *Titan* and ask slyly: "What scale is it?"

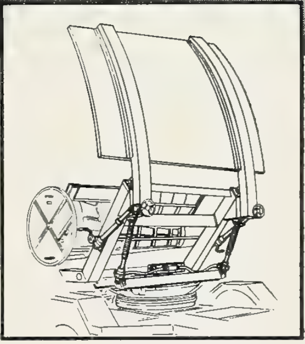
There are indications the public does not, and does not share the Administration's lack of concern. A recent newspaper poll in Los Angeles on the subject brought an unprecedented and overwhelming reply with three out of four persons saying they are "ashamed" of our place in the space race. Six out of 10 wanted the U.S. to catch up even at the cost of reducing the U.S. standard of living. More than half said they would be willing to pay $50 a year more in income taxes if the money were allocated to the space program.

We cannot escape the feeling that this public awakening will be reflected in a campaign issue in 1960, that it may even become the hottest issue of all. That a great many voters will seek an answer for our failures and demand a placing of the blame.

CLARKE NEWLON

Diversified electromechanical systems capability





U.S. Army Signal Corps ground portable radar unit operated with two AiResearch electromechanical actuation systems.

AiResearch Actuation Systems For Portable Radar represent a typical electromechanical systems application in ground support equipment. Two types of AiResearch actuation systems are now in production for the Army's mobile trailer-mounted ground radar unit. They consist of a manually operated antenna folding storage system and an electrically powered antenna elevation system.

Designed to operate under the most severe environmental conditions, this type of electromechanical system can operate on 60 cycle A.C., 400 cycle A.C., or 28 volt D.C. Other suggested applications include: *missile launchers, missile ground handling and support equipment, armored vehicle fire control and ballistic handling systems, and mobile communications equipment requiring servoed actuating systems.*

AiResearch leadership in the development and production of electromechanical equipment for aircraft, ground handling, ordnance and missile systems of all types also includes such recent examples as spoiler servo control systems, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting. We invite you to submit a problem statement of your electromechanical requirements.

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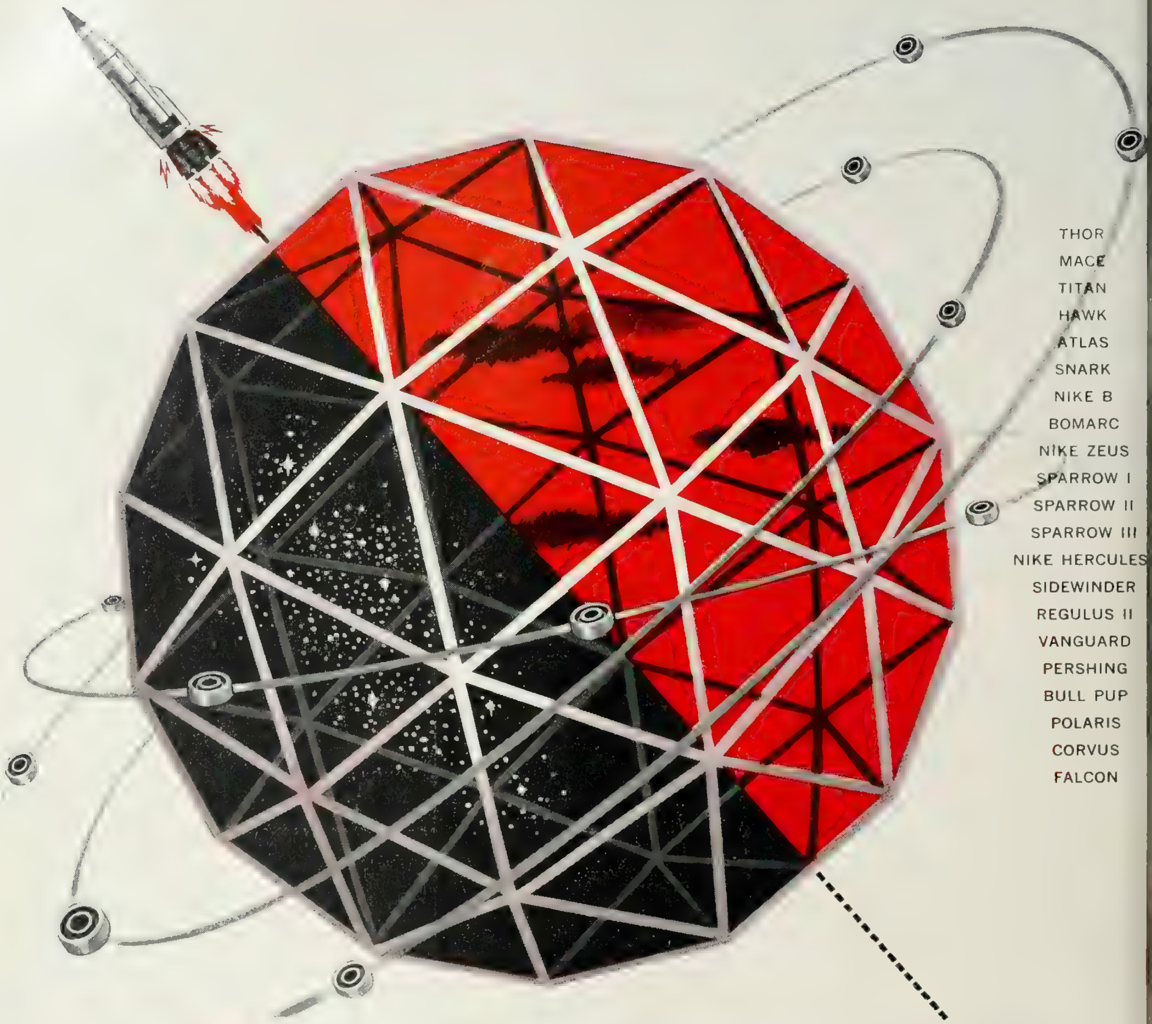

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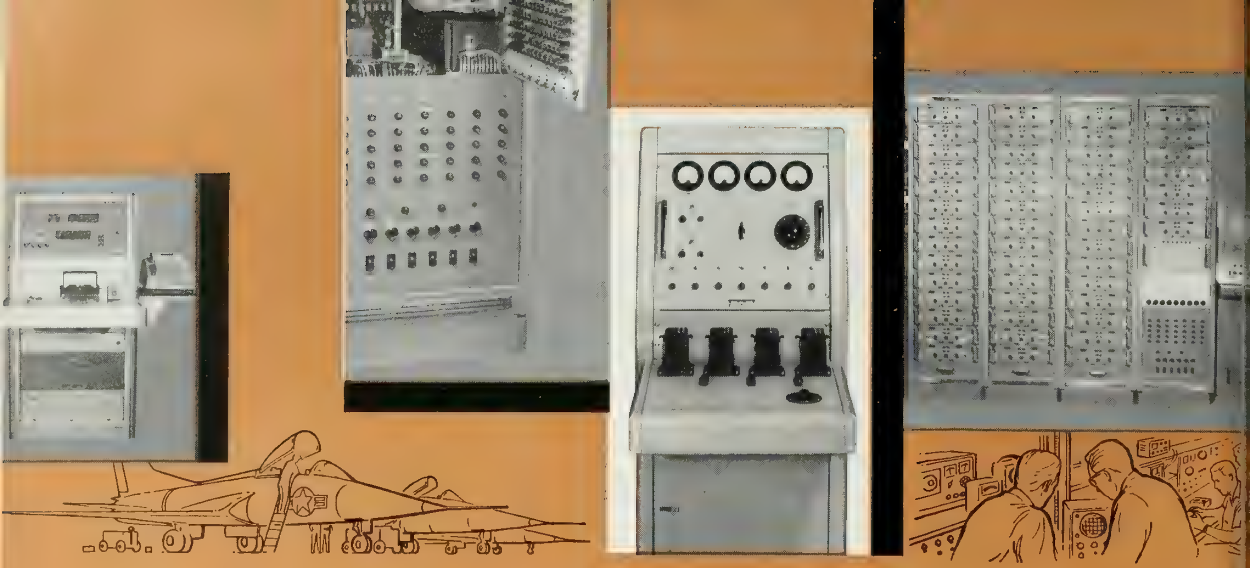

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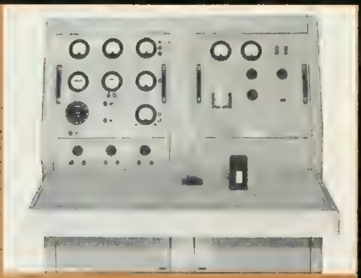

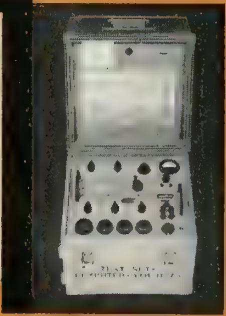

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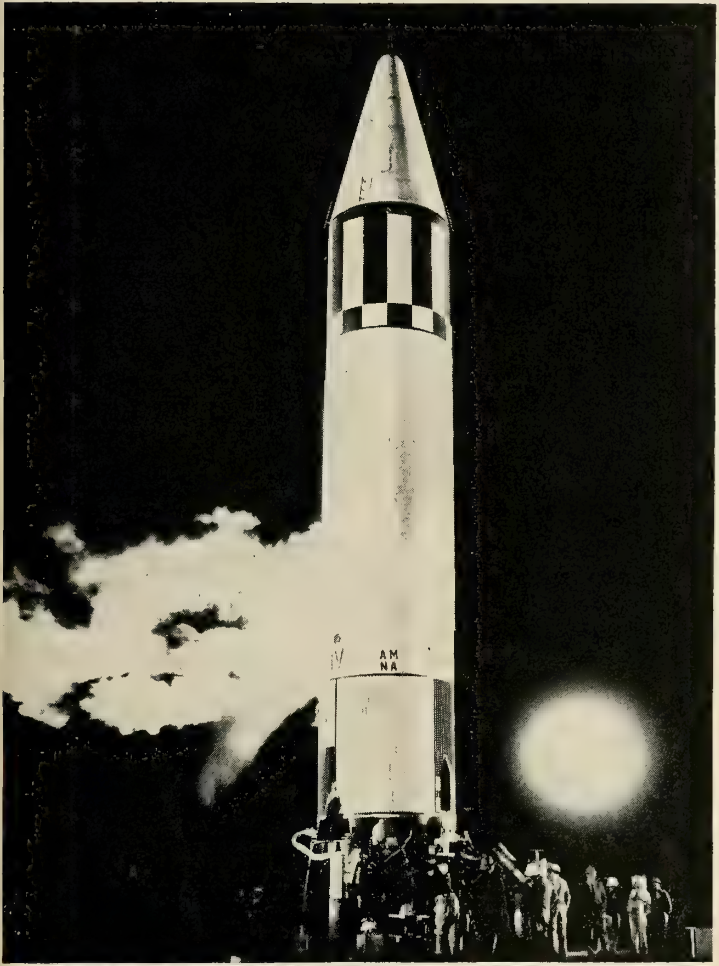

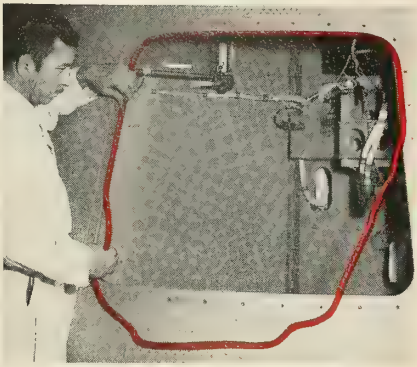

Silastic was specified for the Jupiter's instrument compartment access door seal. The Silastic seal has better storage properties and can better stand high skin temperatures. Wire bundle clamps in the compartment also utilize Silastic.

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Missiles and Rockets Volume 5 Number

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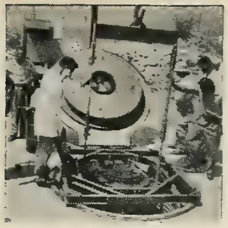
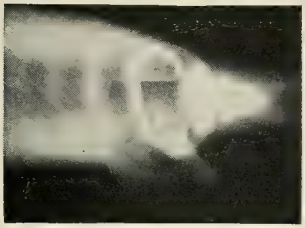
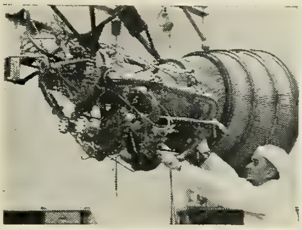


COVER: The *Nike-Zeus* sustainer unit, which has a propellant weight of probably 7000 pounds, is lowered into casting oven at Grand Central Rocket Co. The Redlands, Calif., firm has the world's largest solids mixer.



CONE SAMPLE in first shock node of jet stream during tests at The Research Institute of Temple University. For a report on the institute's study of high temperature flames, see p. 17.



LIQUID propellants for this Pratt & Whitney *XLR-115* engine, which will power the upper stages of the *Atlas-Centaur* space vehicle, are pumped with unusual system. See p. 19.

LOAD CELL calibrated by the National Bureau of Standards is used in missile test stand to measure rocket thrust. Other Bureau services to missile/space programs are described in story starting on p. 30.

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

32,000 copies of this issue printed

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The year will see the dropping of marginal programs and increasing mergers and consolidations within the industry; there will be more spending in some areas 15

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Advanced degree in M.E. preferred with experience in the design of aero and thermodynamic missile scale models including previous work in wind tunnel model design and test. Shop liaison experience desirable.

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Advanced degree preferred for basic and applied research in one or more of the following areas: metallurgical behavior and mechanisms concerning high temperature and advanced missile materials with interest in metal physics; deformation and fracture; phase equilibria; transformations; or diffusion. Also, to conduct basic and applied studies in refractory metals; dispersed phase systems; fiber metallurgy; ceramics and thermal protective materials systems. Also, for X-ray and electron diffraction research and studies in single crystals; point defects; parameter measurements; pole figure determinations.

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Experience required in MASER amplifiers and variable reactance parametric devices, for experimental research in microwave.

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Washington Countdown

IN THE PENTAGON

Postponement of *Nike-Zeus* . . .

production for at least one year could mean a loss of up to two years in the program. That means that the big **Western Electric** AICBM cannot be operational before 1965—after the coming Missile Gap.

• • •

The double loss . . .

for *Zeus* results from the Army's cramped R&D budget. The Army had $135 million set aside for long-lead-time *Zeus* production items. Now that money is expected to be spent on R&D missile projects and other advanced weapons.

• • •

Military missile launchings . . .

from Cape Canaveral during the second half of December are expected to include:

. . . A **Martin** *Titan-C.*

. . . A **Chrysler** *Jupiter.*

. . . Two **Lockheed** *Polarises,* one from the **Loewy-Hydropress** ship motion simulator.

. . . A **Douglas** *Thor.*

. . . A **Norair** *Snark.*

• • •

The next Air Force *Discoverer* . . .

launching is expected next month at the earliest. It's understood that no decision has yet been made on whether it will involve only another attempt at recovering a capsule from orbit . . . or possibly a more advanced experiment.

• • •

Air Force money shortages . . .

are holding up award of contracts on two big projects—the hardening of NORAD facilities and *Quickglobe.* The latter involves presentation of large amounts of data for rapid decisions during an attack.

• • •

The latest ARPA shakeup . . .

is a clear-cut victory for Pentagon R&E Chief Herbert York. The agency, which has operated on equal terms with the three military services, is now responsible to York and is headed by his former military assistant—Brig. Gen. A. W. Betts.

• • •

Project *Vela* . . .

is an ARPA program aimed at developing devices for detecting nuclear explosions. ARPA has been working on the previously-secret project for the last few months.

AT NASA

The civilian space budget . . .

for FY '61 is now pegged at about $750 million. However, some top NASA officials are secretly in hopes that Congress will override the White House-enforced budget in the face of continued Soviet space successes.

• • •

Another delay for *Scout* . . .

the so-called poor man's rocket, is in the works. Originally initial flight tests for the **Chance Vought** vehicle were scheduled for September. Then they were postponed until January. Now they're expected in March.

• • •

A big liquid hydrogen engine . . .

development program is scheduled to be started by NASA in FY '61. The new NASA budget will include initial funding for development of the clustered half-million-pound thrust-engine. Total expected eventual cost: about $100 million.

ALONG EMBASSY ROW

The third BMEWS station . . .

is expected to be built in the wild Scottish highlands. The huge RCA facility—to be operated jointly by Britain and the United States under a recently-announced agreement—will tie in with the other two ICBM early-warning stations at Clear, Alaska, and Thule, Greenland. The long-range radar net—scheduled to be operational by 1961—is designed to give a 15 to 20 minute warning of a Soviet ICBM attack.

• • •

Japanese missilemen . . .

have established Japan's first missile air defense unit outside of Tokyo. The 145-man unit is part of Japan's Ground Self-Defense Force.

AROUND TOWN

Some of the "Reports" . . .

being heard around the nation's capital:

. . . The Democrats are having trouble on agreeing what is the best way to attack the Administration's space program.

. . . Russia is continuing to lob its ICBM's over the Japanese Islands into the Pacific.

• • •

Incidental space intelligence . . .

An enterprising merchant in Cheyenne, Wyo.—center of the nation's first complex of *Atlas* squadrons—has dubbed his business: Bart's *Atlas* Pawn Shop.

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- Pressure rises from 50 to 2000 psi
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- Leakproof sealing systems for safely handling hazardous fluids
- Variable-speed electric motor pump drive for varying pump output requirements

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Engineers, scientists — investigate outstanding opportunities at Aerojet

Industry Countdown

MANUFACTURING

ICBM bases are hard hit . . .

by the strike-caused shortage of structural steel. Construction of the launch facilities for the second *Atlas* squadron at Warren AFB is being delayed now and officials say the program will be "in real trouble" if the steel strike is resumed.

• • •

Convair has edged out . . .

General Electric in the dragged-out competition to develop the Army's *Mauler* surface-to-air missile. The initial contract for the IR-guided weapon is expected to run over $10 million.

• • •

Willow is a new . . .

missile project just unveiled by the Army in the award of a $500,000 R&D contract to **Chrysler Corp.** Work on the classified program will be done at the Michigan Ordnance Missile Plant in Detroit.

• • •

Expect the DOD budget squeeze . . .

to result in a sharp cut-back in government financing of defense plants. The Air Force now is telling contractors it will invest its funds in "brick and mortar" facilities only in extreme cases. If this policy is pursued, it could exert considerable pressure upon Congress to revive the fast amortization program which expires this month.

• • •

Big recruiting drive . . .

for scientists and electronics engineers will be staged by **Boeing Airplane.** The company needs 1300 persons in these categories, largely for its *Bomarc, Minuteman* and *Dyna-Soar* programs.

PROPULSION

Insulation difficulties . . .

apparently have been overcome in the second-stage case of the *Minuteman* ICBM. The lining burned out in an early test of the case—manufactured by **General Electric**—but survived when it was successfully fired at **Thiokol-Utah** on Dec. 3.

ASTRIONICS

Reports of injury . . .

to personnel from microwave energy are being debunked by Col. George M. Knauf, tri-service coordinator for investigation into microwave energy hazards. Knauf says there are "no proven" cases to date (see page 20).

• • •

Gallium phosphide . . .

is a new metal developed by the Army Signal Corps for diodes which can withstand temperatures seven times higher than the maximum for silicon or germanium—up to 1500°F. The Army believes GP may solve the heat problem in missile nose cones.

• • •

"Clo" as a measure . . .

of clothing warmth for astronauts is suggested by a University of California associate professor—J. W. McCutchan. One "clo" would be that quantity of clothing that will maintain a comfortable heat balance for a man sitting at rest in a room with a 70°F temperature, less than 50° humidity and a 20 fpm air movement.

WE HEAR THAT—

Despite steel shortages . . .

outfitting of the *Titan* silos at Vandenberg AFB is proceeding on two shifts a day and may soon swing into three shifts . . . The Navy will soon let contracts for the conversion and instrumentation of a third Victory class ship to be used in the Pacific Missile Range . . . **Minnesota Mining & Mfg.** is building a $10 million, 14-story administration building at its St. Paul research center . . . Switching the name of its Research Department to Research Laboratories, **United Aircraft Corp.** says the East Hartford, Conn., facility will now concentrate more on fundamental research —including solid-state physics and plasmas and ionized gases . . . **Fruehauf Trailer Co.** has established an integrated missile products division in Los Angeles entirely separate from commercial production . . . In the press center of the 706th Strategic Missile Wing at Warren AFB there is a picture on the wall of an *Atlas* blasting off its pad. Under the picture someone has inscribed: "If you care enough, send the very best."

More About the Missile Week on Page 42

FABRICATION TESTS SHOW...

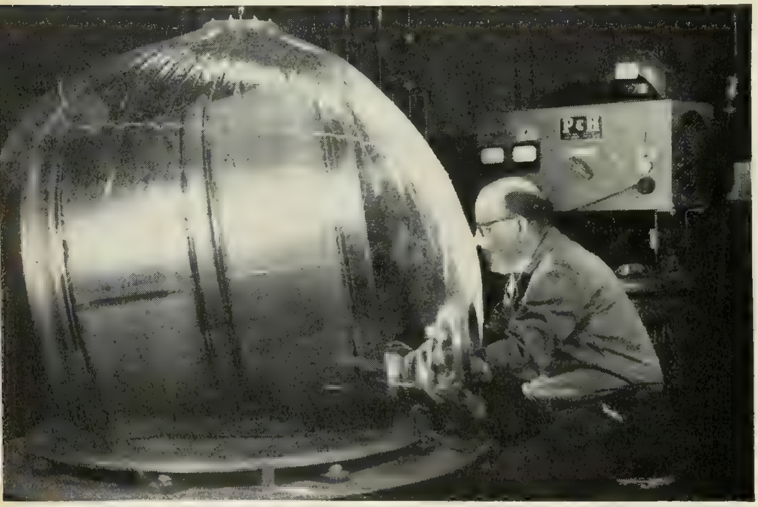
New Titanium alloy takes t

...in strength...in weight...in reliability...in pr

Titanium rocket-motor cases can be built at least 30 percent stronger (or lighter) than best available alternate metals; provide permanent corrosion resistance without protective coatings; withstand temperatures from –400°F to +800°F; will not absorb moisture which distorts critical parts in storage.

Completed assemblies give a spectacular two-way pay-off . . . immediately; provide a growth potential virtually unlimited.

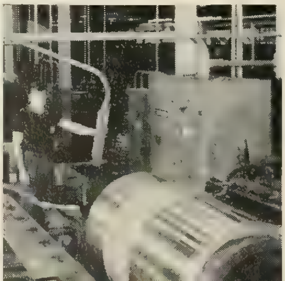
The alloy: Ti-13V-11Cr-3Al, the beta titanium alloy. Now available from Titanium Metals Corporation of America at commercial lead-times (billet, 2-3 weeks), beta may well become the metals story of the year.



Welding of titanium at P&WA is based on the company's experience in production of more than 5800 jet engines containing titanium parts. Weld strength of beta titanium alloy is considerably improved by cold working the weld.

End Closure Titanium Forgings produced by Wyman-Gordon Company and machined by P & WA, will be *girth welded* to the flow-turned cylinders. Bosses are an integral part of the closures.

Flow-turning from roll-forged rings, makes feasible production of full-scale titanium rocket cases, since it yields integral cylinders, eliminates need for longitudinal welds, conserves input metal.



Pilot rocket-motor cases manufactured b
& Whitney Aircraft from beta titaniu
Ti-13V-11Cr-3Al have been consistently
tested at levels in excess of 235,000 psi –
strength/density ratio of 1,340,000.

So successful has been its titanium pr
that Pratt & Whitney Aircraft conside
production of full-scale titanium cases
easily realized. Estimated initial burst stre
a conservative 180,000 psi – a burst str
density ratio of 1,000,000. Readily attai
1,250,000.

Reasons for optimism, spelled out by P
engineers are:

1. **"The welded beta titanium alloy is capa
considerable plastic deformation prior t
ture. As welding has improved, the f
origins have moved into the thin wall
case itself). With beta titanium, the case
but doesn't fragment.**

2. "We have successfully tested small scale ti
cases with a steel equivalent yield strengt
beyond the 300,000 psi point. Considerin
the metallurgy of metastable beta titanium
is not far beyond its infancy, conservative
would predict strengths substantially highe
the 320,000 psi equivalent as being
possible.

3. **"Beta titanium has to develop (only) 140,
to be equivalent to 220,000 psi steel (w
almost near steel's top limits). But tita
great potential above other alloys is refle
the high figure for practical (based
elongation) yield strength. At 180,000
titanium is equivalent to steel at 280,000
200,000 psi, beta titanium is equivalent to s
320,000 psi. 200,000 psi in beta titanium is
ble, and obviously would mean substantia
creased payload to the moon or out into**

4. "Apart from the strengths attainable in th
titanium alloy, there is another property o
siderable significance. Like other titanium
it has excellent resistance to corrosion
normal atmospheric conditions, in salt wa
well as in many other media.

***"In considering the long time storage pro
with rocket cases – a pit in a thin-walled
can be catastrophic – we would regard th
titanium alloy, as the outstanding ma
under consideration."***

ead in rocket case construction

PRATT & WHITNEY AIRCRAFT SURVEY OF ROCKET CASE MATERIALS

GENERAL PROGRAM

The goal: "A material capable of reaching 300,000 psi yield strength in steel, with a considerable development margin."

The result: "While this goal had to be modified for steel cases, we have successfully tested small scale titanium cases with a steel equivalent yield strength well beyond the 300,000 psi point."

Conclusions: 1. "By exercising reasonable care, the development of full scale (steel) cases at 240,000 psi is perfectly feasible.

2. "Small scale (titanium) cases have been burst at stress levels as high as 260,000 psi . . . we are convinced that reliable cases can be manufactured (from titanium) at yield strength levels of 180,000 psi and over . . . at 180.000 beta titanium is equivalent to steel at 280,000 psi.

"At 200,000 psi beta is equivalent to steel at 320,000 psi. 200,000 psi beta is possible and obviously would mean substantially increased payload to the moon or out into space."

SPECIFIC COMPARISON: Strength

Alloy	Density	Practical Yield Strength (5% elongation)
Ti-6Al-4V	0.161#/in.^{3}	155 ksi = steel at 270 ksi
Ti-13V-11Cr-3Al (Beta)	0.175#/in.^{3}	180 ksi = steel at 280 ksi 190 ksi = steel at 305 ksi 200 ksi = steel at 320 ksi

Burst Test Results show titanium has provided consistent burst strengths of 235,000 psi — a burst strength/density ratio of 1,340,000. Failure occurs in the wall of the case itself — not the weld zones. Titanium cases do not fragment.

SPECIFIC COMPARISON: Corrosion Resistance

Steel: "All of the low-alloy constructional steels which have been discussed are subject to general rusting and, far more serious, to pitting type corrosion during machining, welding, heat treatment, pressure testing and final storage. Corrosion pits can act as severe stress-raisers and, in conjunction with hydrogen, have been demonstrated to cause catastrophic failure. It therefore goes without saying that pitting corrosion is a serious hazard."

Titanium: "Like other titanium alloys, the beta titanium alloy has excellent resistance to corrosion under normal atmospheric conditions, in salt water as well as in many other media.

"In considering the long-time storage problems with rocket cases—a pit in a thin-walled casing can be catastrophic — we would regard the beta titanium alloy as the outstanding material under consideration."

• Reliability and growth . . . the parallel

Pratt & Whitney Aircraft data reveal rocket-cases can *now* be built from beta titanium at strengths 17 percent greater than alternate metals, with beta titanium's strengths bounding forward under a minimum of development.

A striking parallel exists in liquid-fueled rocketry where titanium alloy Ti-6Al-4V was selected for helium storage bottles in the Atlas missile because of its strength/density ratio. Airite Products, Inc., a leading supplier of the titanium vessels, reports:

"Minor modifications in processing techniques and continuous tightening of tolerances and other variables have shown an increase from the original 5400 psig average burst pressure to the present average which is in excess of 9000 psig.

"This has been done without increasing the weight of the article by one ounce. Weight of the unit, incidentally is controlled to a tolerance of plus or minus one-half pound, on a weight of 79 pounds, and volume is controlled and guaranteed to plus or minus one percent."

While the performance of the titanium pressure vessels has been almost doubled, the price has been reduced almost 50 percent — and the missile has become operational.

• When a case fails, so does the missile

The price of completed beta titanium rocket-cases is now estimated at 2½ times the price of other metals, with titanium cases virtually in their infancy. Should the titanium cost difference remain, the pay-off would still be two-fold:

1. **Cost:** engineering time, would be greatly curtailed; expensive fuels (for example, 30 pounds of fuel are required in earlier stages for each additional third-stage pound) would be saved.

2. **Reliability:** titanium cases simply will not pit, rust, deliquesce, or become hydrogen embrittled.

Added together, these elements mean feasibility—feasibility supported by the commercial availability of the metal itself. Beta titanium alloy Ti-13V-11Cr-3Al is available from Titanium Metals Corporation of America at these lead times: billet, 2-3 weeks; bar, 3-4 weeks; flat-roll, 5-6 weeks. TMCA's metallurgical experience with the alloy is yours for the asking.

For further information, write for TMCA Data Bulletin *All-Beta Titanium for Solid Rocket Pressure Chambers*. Extensive welding information is included.

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clasp 40-foot Bomarc around its ta
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countdown, whether or not the bi
goes, this system releases only o
positive, upward movement th
actuates a valve in the pad. B
because all mechanical devices c
fail, an emergency release syst
was also needed...

So, he put a small lever at the e
of each arm. This lever makes act
contact with the bird. As Bom
moves up, these levers rotate with
After an inch of movement, th
automatically snap the arms out
the way if the basic system has
already done so. Even in a wind th
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Bomarc won't get bumped. Sim
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neering and production capabilit
Its purpose: to accept assignme
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DOD Funds Will Be Tight in '60

Many 'marginal' programs will be cut back and foreign missile competition will be stiffer; mergers, consolidations are likely

by Betty Oswald

WASHINGTON—In Calendar 1960, the sprawling U.S. missile industry will face the countdown of its life.

Lines will hold tight on availability of funds, and they are likely to get tighter as the Administration and Congress gird for the next national election.

U.S. missile makers will face increasing competition from foreign manufacturers.

The year will see the cancellation or sharp curtailment of many "marginal" programs.

Industry will have to merge and consolidate in an effort to provide new capability in some program areas.

The Administration is firmly committed to a spending program in both Fiscal 1960 and Fiscal 1961 of about $41 billion for defense. And there is very little chance that Congress will change the numbers much, even though it would take $45 billion in FY 1961—and even more in years to follow—to adequately fund more than 25 peaceful space missions and some 65 missile programs.

The principal effort of Congress will probably be to see to it that spending plans are kept flexible, to take advantage of breakthroughs or changes in technology which might reduce the now almost certain long period of catching up with Russia.

• **Tightening belts**—This means that Calendar 1960 will be increasingly a time of "selection", reducing the total number of programs. It means, too, that competition will increase for the dollars which are almost certain to get scarcer for research and development in new program areas; mergers and consolidations will be required in order to achieve the goals that both Pentagon and NASA will demand. A company will be increasingly unable to "go it alone," providing on its own the skills or managerial talents required to keep its place in the industry—let alone to strengthen its position.

A look at the foreign market is even more disheartening. France has some 14 missiles under development and is acquiring a good in-house capability, particularly in instrumentation and solids propulsion. Great Britain is producing some seven different missiles, and—putting a reverse twist on "buy American"—has succeeded in selling its anti-aircraft missile, *Bloodhound*, to both Sweden and Australia. Even the neutral Swiss and Swedes are coming up with missiles of their own. To meet this competition from abroad, U.S. manufacturers will be faced with establishing more branch offices in Europe, increased sales pitches to NATO, and licensing agreements with more foreign manufacturers.

• **Limiting decisions**—A major factor is, of course, the continued increase in costs of new systems which must be fitted in under the tent of the U.S. budget ceiling. This means that judgments must be made earlier than the decision makers like. It means that parallel approaches to a single problem can't be taken unless an extraordinary need exists. And this, in turn, means that decisions which should be made promptly probably won't be made because nobody will want to guess wrong.

Choices will be made not only on numbers of missiles and space vehicles to be produced, but also between programs. The decisions will be ones of emphasis—that is, the forces and weapons required for strategic deterrence, for air defense, for antisubmarine warfare, for limited warfare.

In the area of strategic deterrence, big long-range surface-to-surface missiles—*Atlas, Titan* and *Polaris*—are all moving rapidly into the production-for-inventory category with all of the accompanying costs for base construction, ground support, spares, maintenance and training. All anyone can look for in this field for the next year or two are so-called product improvement programs rather than new missiles.

• **Some exceptions**—There is one important exception—in the area of propulsion. Neither the Air Force nor the Navy is satisfied that the answers are all in yet on solid propellants; there will be money available for pushing forward in this field. Also, ways and means will have to be found to reduce the CPE (circle of probable error) on the small warheads—*Polaris, Minuteman*. It's in this area, Air Force and Navy officers say, that the continued ban on nuclear testing is hurting badly. Nevertheless, Defense Secretary McElroy, now resigned, told a farewell news conference that a *Polaris* weapon system would be delivered approximately every four months for the foreseeable future once an initial operational capability was acquired in late 1960. *Minuteman's* future also looks bright with McElroy promising "optimum" funding in the new budget to provide missiles in place by 1963.

In the case of *Titan* there will be "at least" 11 squadrons. And, after the sixth, AF hopes to have a usable, storeable liquid propellant, and to fire the missile out of its silos.

• **Missiles for troops**—While the Army is out of the big surface-to-surface missile business, it has a big stake in missiles for use by the troops and Dr. Herbert York, Defense Dept. Research and Engineering chief, is said to have a more "imaginative" approach to the problems of limited war.

Pershing, the successor to *Redstone*, solid-propelled, is in the last stages of development, with $130 million for the missile in Fiscal 1960, compared with $100 million in Fiscal 1959. A second missile, *Sergeant*, also a member of the new generation, will take the place of *Corporal* sometime in 1960.

And Army has some even newer missiles coming along, including *Lobber, Mauler, Shillelagh* and *Red Eye*.

It's in the area of air defense and, later, space defense that the biggest question marks exist. A sign of the times was the recent decision to stop work on the new underground headquarters for NORAD, admittedly a prime target for any attacking force.

• **Air defense uncertainty**—Another and perhaps even more important sign is that there is a new move to revise the "Master Air Defense Plan" under which the Army's *Nike-Hercules* and the AF's *Bomarc* program were cut back last year. There is strong feeling at the Pentagon that there is no immediate prospect of finding a solution, either partial or total, to the air defense problem. Even in the "good old days" of the B-29, the prediction was that a very substantial part of the attacking force would get through, and with missiles instead of aircraft carrying megaton loads a partial defense isn't considered good enough. Hence, the argument that reliance ought to be placed almost entirely on retaliatory forces, with little or no money made available for air or space defense. Advocates of this doctrine got strong support last year from Project *Argus*, which showed how a space explosion might wreck the communications on which air defense is based.

This doesn't mean, however, that the problem of air defense is being completely overlooked. *Nike-Zeus* won't be put into production or readied for production. However, it will receive "generous" funding for research and development—just in case.

Bomarc B will be funded through Fiscal 1960, which ends next June 30. At that time a program—although not the production one—for about 30 units of equipment (missile installation) will be funded out, even though production and construction for the job won't be complete. Plans to put SAGE underground—plans on which *Bomarc* is at least partially dependent—won't be carried forward unless a major change is made in current thinking on air defense.

And *Bomarc* and *Nike* are not the only two victims of the growing uncertainty of air defense. Navy *Terrier* and *Talos* missiles are likely to be cut back following a decision to go slow on building ships which would use these anti-aircraft missiles.

The F-108, Mach 3 long-range interceptor, was also a victim. While it is now considered possible that AF might buy a proposal for a "technically uncomplicated" F-108, the future of the super *Falcon (GAR-9)* which would have armed the F-108 hasn't been decided—despite a decision to continue development funding on a limited basis.

• **Limited future**—Development and production of such missiles as *Sidewinder*, *Bullpup*, and *Sparrow III* will be continued. Here, however, the problem is what comes afterwards, since it's a virtual certainty that there won't be any new interceptors of any important range after the F-106 and the Navy's F4H. This leaves it open to question whether Navy will get the funding to push the *Eagle* project beyond its present level.

Similarly—since the future of the bomber fleet will be in doubt after the current family of B-52's, a limited number of B-58's and F-105's and the Navy's A3J—there's some question as to the value of the air-launched-ballistic missile contract recently awarded to **Douglas Aircraft.** As matters stand now, *ALBM* will be funded in research and development—but only with the *Hound Dog* scheduled to go on the B-52. McElroy told his news conference that the U.S. was counting heavily on the *Hound Dog* in the era ahead when a missile gap in favor of Soviet Russia is a virtual certainty. AF choice will be between product improvement of the *Hound Dog*, which now has a range of some 500 miles, and development of *ALBM*. Odds favor *Hound Dog*.

• **Drones & ASW**—There will, however, be work in one field of air defense. Army will continue development and production of missiles for the defense of troops, with major emphasis on the *Hawk*. It will also continue development of drones to survey enemy terrain, take pictures and return to land by parachute. All three services are interested in drones. Navy sees their possibility as a tool of antisubmarine warfare. AF wants them for targets and Army wants them for both targets and reconnaissance. It's an area in which development dollars will be spent in substantial quantities next year, even though no firm figures are available.

Another area in which funding can be expected is that of anti-submarine warfare. There is a slow growing realization both in the Pentagon and on Capitol Hill that if *Polaris* submarines are as effective as we like to believe, this kind of weapon is even more dangerous in the hands of the Russians. At least three major projects are under way, all highly classified. Here, there is the warning of Rear Admiral Paul D. Stroop, first chief of the newly created Bureau of Naval Weapons, that decisions will be made at the conclusion of research and development—that the Navy can't afford a diversity of weapons in inventory.

• **Space for civilians**—Beyond missiles, there is, of course, space. Looking at it only from the Pentagon's point of view, there is still no clear-cut opinion on the value of space for military operations. Interest centers in such projects as the reconnaissance satellite, now known as *Samos;* the early warning satellite for missile attack, *Midas;* and the communications satellites. As of now, the feeling is that space explorations will be civilian in character—that current boosters are adequate to meet military needs. Change can come only after the *X-15* and perhaps later *Dyna-Soar* make the first excursions into space.

In the meantime, the danger facing the National Aeronautics and Space Administration and its contractors is that Congress has almost always taken the attitude of "millions for defense" and non-defense activities have always been cut to fit into fiscal plans—whatever they might happen to be. As one informed source put it: "How much will the people of the United States pay for prestige unless the value of space is defined in language that they can understand?"

SEPR Advances

French Firm Develops Solid-fuel Engines

PARIS—**SEPR (Société d'Etude de la Propulsion par Réaction),** a French company specializing in the manufacture of rocket engines, is now going ahead with development of solid-propellant rocket engines. At its test benches at Istres, SEPR recently fired a rocket loaded with one ton of solid propellant, an achievement believed to be unsurpassed in Europe.

Details have been released about the *Matra 511* air-to-air missile which is now in production to arm the latest French fighter types (Vantour, Super Mystere, Mirage III). The missile has a length of 3.10 m (10′), a diameter of 0.26 m (10″) and its launching weight is 180 kg (397 lbs).

It has a two-stage, solid-propellant engine, the first stage delivering a thrust of 1.600 kg (3.527 lbs. during three seconds), the second stage 200 kg (440 lbs.) during 13.5 seconds. The range is between five and seven km (3.10 to 4.35 mi.). The speed of the missile related to that of the fighter is of 280 m/sec. (92 ft./sec.). The *Matra 511* has been developed for either infrared or electromagnetic self-guidance. An Andyar battery supplies the power.

Temple Studies High Temperature Flames

Aerodynamic heating over 4000°K created to determine effects and nature of combustion processes

CONE SAMPLE is shown in the first shock node of a jet stream. The exposure used is 1/250 that of normal daylight.

by William L. Doyle*

ELVERSON, PA.—The Research Institute of Temple University has long been investigating high temperature flame studies of a premixed bunsen burner type to determine the effect on materials and the nature of combustion processes.

As a result of these investigations, early in 1955, conferences were held between personnel of Redstone Arsenal and the Research Institute of Temple University. Purpose was to explore the possibilities of actually constructing a rocket test facility using substances from pre-mixed flame studies which would produce supersonic jet streams for aerodynamic heating tests.

It was then decided to design, build, and operate a test facility for a small rocket motor with a 2″ diameter circular exit. The jet stream produced by this rocket motor would provide aerodynamic heating in excess of 4000°K (6740°F) by combusting hydrogen cyanide with an equimolar mixture of fluorine and oxygen as indicated in the following equation:

$$2HCN + F_2 + O_2 = 2CO + 2HF + N_2$$

(Equation 1)

This system became known as the liquid hydrogen cyanide system.

The calculated flame temperature of this reaction, at the stoichiometric point, is 4410°K (7480°F) at 300 psia chamber pressure for the substances in their liquid states.

After considering the handling, metering, and other problems associated with this propellant combination, it was decided to flow them in their respective liquid states. It became necessary to ignite the propellant combination when the reactants were in gaseous states, at pressures slightly greater than atmospheric.

It was predicted—and later found true—that this combination would be hypergolic in the liquid state, due to the tremendous increase in atomic concentration. The first test was completed in July, 1956 and since that time approximately 200 have been run with this system at 300 psia chamber pressure and several at 500 psia.

Another propellant combination was considered in the early plans, namely, the liquid cyanogen-liquid oxygen system, which reacts as follows:

$$(CN)_2 + O_2 = 2CO + N_2$$

(Equation 2)

and became known as the liquid cyanogen system.

The flame temperature for this reaction, at the stoichiometric point and 300 psia chamber pressure, is 4860°K (8288°F). This system has the advantage of containing no HF in the jet stream, i.e., the behavior of the gases in the jet stream would more nearly approach those of the atmosphere. This latter combination, however, is nonhypergolic, and a flourine ignition system had to be employed.

Since cyanogen was available only in very small quantities (which were sufficient to carry on the pre-mixed flame studies at the main laboratory), the liquid cyanogen-liquid oxygen system was not considered for the initial tests. The **American Cyanamid Company** did construct a pilot plant at Stamford, Connecticut, which produced enough cyanogen to begin initial testing by the end of 1956. Since that time approximately 100 tests have been completed at 300 psia.

Most of the tests have been at approximately 300 psia chamber pressure and both will be increased to 500 psia chamber pressure. These aerodynamic heating tests are used for materials testing and both conical and flat plates have been placed in the jet stream.

A probe was used for determining relative heat fluxes of the nozzle jet stream under various conditions. The absolute values of the streams were determined by very complicated molybdenum calorimeters. These calorimeters have been fabricated at the Army

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**Director, High Temperature Test Area, Research Institute of Temple University*

Ballistic Missile Agency. Purpose of the simplified probes was to correlate the results of varying conditions with those of values obtained from Redstone calorimeters. Test results, are still being evaluated. Heat probe tests from issuing jets from contoured nozzle chambers were not completely streamlined, but were nearly uniform in heat flux output. This is in contrast to jets from standard conical type chambers where the heat flux outputs were more than 50% less in the area one half the distance from the nozzle to the first shock nodes as compared to the output in the shock node.

- **Methane system**—Initial tests on a third system—the methane-oxygen-fluorine system—which reacts according to the following equation:

$$2CH_4 + O_2 + 3F_2 = 2CO + 6HF + H_2$$
(Equation 3)

have been performed here recently, and is designated as the methane system. This system was chosen because it had approximately the same chamber temperature as the hydrogen cyanide system, but a much higher jet velocity. Hence, it should shed some light on the effect of jet velocity on the heat flux output to a sample. In Equation 3 we plan to alter the proportions of fluorine to oxygen. The amount of oxygen will always be sufficient to oxidize the carbon to carbon monoxide.

This methane system presents a very interesting picture. For it and the other two high temperature systems, have carbon monoxide or nitrogen, as reaction products. These are the most stable molecules known and no appreciable dissociation occurs with below 4800°K (8180°F) at 300 psia chamber pressure. Therefore, CO and N_2 act as diluents below 4800°K while HF can be considered a diluent and is only partially dissociated at the chamber temperatures of the systems considered. CO and HF act as diluents to the free hydrogen in Equation 3 to cause its further dissociation at a particular chamber temperature and pressure. Further, the dissociated hydrogen would tend to repress the dissociation of the HF. Obviously, the energy gained by the recombination of the dissociated chamber products during the expansion process are not considered in frozen calculations and hence such values would be low and unrealistic.

In earlier fluorine work done at Ohio State University, not only was the density of fluorine in question but also its heat of dissociation. It was found that the density of fluorine was increased by 1.108 g/ce to 1.51 g/cc (at–188°C) (–306°F) and that the heat of dissociation of 64 Kcal/mole was to be reduced to 32, 35.5, or 36.6 Kcal/mole.

The latter value is used here. In NACA theoretical studies the value of 35.5 Kcal/mole was used. The difference in these two values would cause a difference of 50°K (90°F) in the chamber temperature.

Since the heat of dissociation of HF has a marked effect on chamber temperature of all fluorine systems, it is expected that there would be a much greater effect on the methane system. If it were found that the higher value for the heat dissociation of fluorine was correct, the increased chamber temperature would allow for a greater amount of methane to be used with the oxidizer.

The oxidizer would contain more oxygen resulting in formation of more free hydrogen. This, in turn, will have a more pronounced effect in the methane system than in the liquid hydrogen-liquid fluorine system since in reality the methane system is a partial "atomic hydrogen" propellant system and doesn't have to boil its diluted hydrogen from a very low temperature.

The early results from the methane system indicate it to be one of the top chemical performers. This system will bear close scrutinization from both the standpoint of a fundamental understanding of the problems associated with high temperature and also the problems associated with dealing with high heat flux outputs to materials placed in the jet stream.

- **Ozone**—The liquid hydrogen cyanide system referred to as Equation 1 was the original propellant system tested here. The stagnation temperatures were increased from 4410°K (7478°F) to 4470°K (7856°F) by increasing the chamber pressure from 20.4 to 34.0 atmospheres assuming a value of 36.6 Kcal/mole for dissociation of fluorine. The chamber temperature of this system can also be increased about 150°K by substituting ozone for oxygen in Equation 1 with no increase in chamber pressure. The possibility of using ozone in this system has been enhanced because of results of recent tests at the main laboratory of the Research Institute where ozone has been found to be miscible with fluorine in all proportions.

This is in contrast to an ozone-oxygen solution which has a maximum of 18% ozone in liquid oxygen at –196°C (–321°F). Further, the work included small micro rocket tests using ozone and fluorine mixtures plus ozone-oxygen-fluoride mixtures. These tests, while on an extremely small scale, indicate that ozone may be considered in larger scale tests as the scale used at the High Temperature Test Area. It is noteworthy that the main laboratory also has found a method of storing pure ozone in cylinders without decomposition for a considerable period of time.

If a well-designed injector is used, the cyanogen system produces characteristic velocities of 5500 ft/sec without corrections to the coolant water. This value is a little over 90% of the theoretical which is in contrast to approximately 100% theoretical for HCN system under the same conditions (frozen equilibrium calculations).

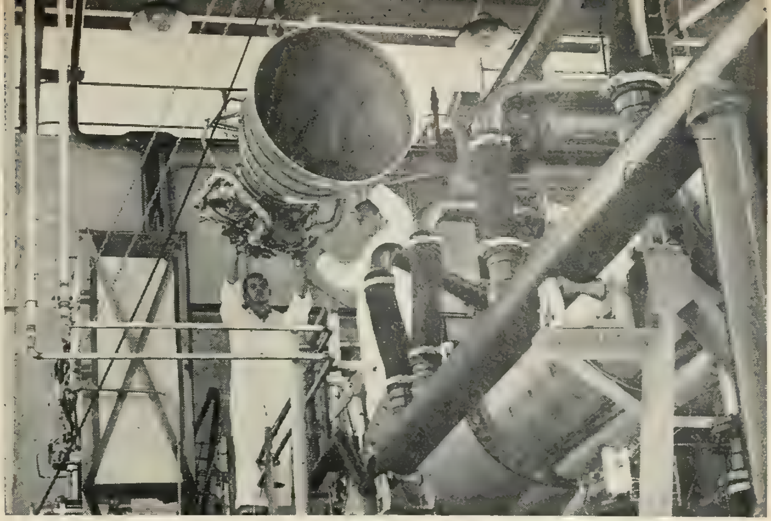
When the cyanogen system is slightly over-oxidized, naturally there is a decline in chamber temperature due to heating and dissociating the excess oxygen. However, the heat flux to the motor walls always increases. This is another proof that chamber temperature was not necessarily the principal criteria for the difficulty in cooling the motor, since not only conduction, convection, and radiation contribute to the heat flux to the chamber wall but also a fourth, and possibly controlling, factor—the heat released by recombination of dissociated molecules on these chamber walls.

The chamber temperature of the cyanogen system can be raised but very slightly by pressure. However, the substitution of ozone for oxygen in Equation 2 would yield a chamber temperature of 5500°K (9440°F) which is the approximate surface temperature of sun. These statements on chamber temperatures are made to stress the point that only by working with the high temperature systems will we learn how to handle them. There is no doubt that other factors which we are not aware of at the present time will make the handling of much higher chamber temperatures possible and practical. We must not take the attitude of a defeatist and sacrifice performance by lowering the temperature, especially when we are dealing with nuclear systems.

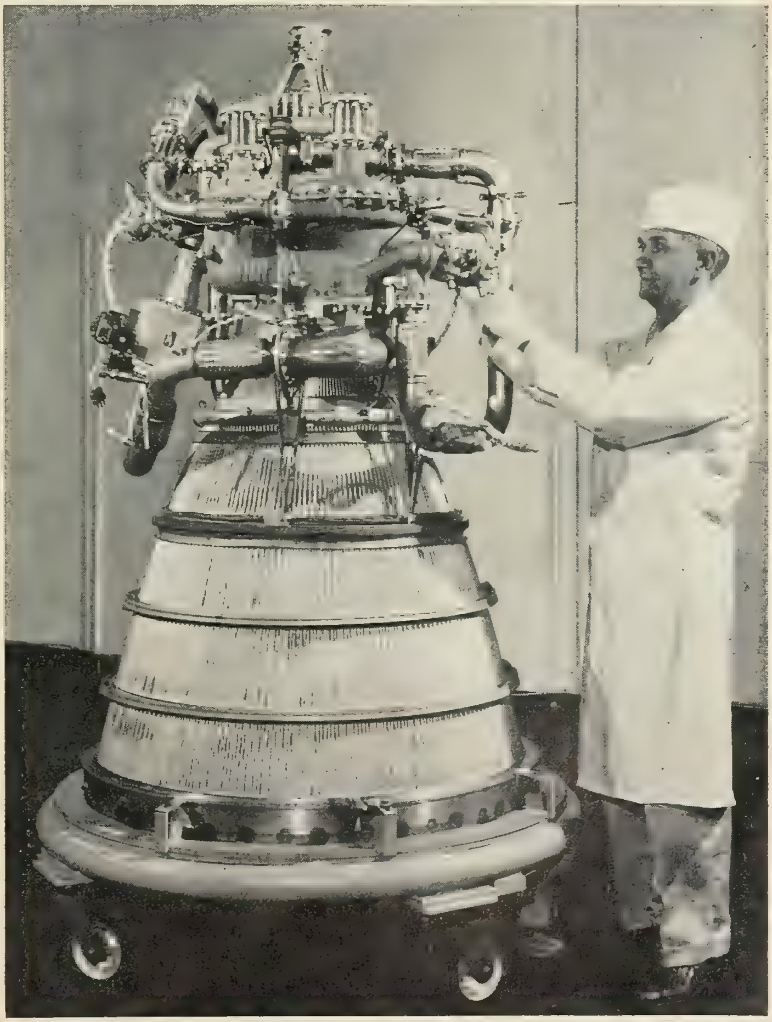
It will be noted that in discussion of all the propellant systems, the important fact—above all—is the use and handling of high flame temperature. It seems apparent that high temperature is the key to high energy regardless of whether we are talking in terms of chemical or nuclear systems. By probing these high temperature systems at elevated pressures fundamental knowledge may be gained which will make breakthroughs in true high energy systems possible.

Extra I_{sp} . . .

Novel P&W Hydrogen Pump Cycle



PRATT & WHITNEY *XLR-115,* the nation's first liquid hydrogen rocket engine, is hoisted to test stand at company's West Palm Beach research & development center.



FIRST PICTURE showing details of the *XLR-115,* which will power the upper stage of *Centaur* and the third stage of *Saturn,* was released for publication last week.

WEST PALM BEACH, FLA.—**Pratt & Whitney** has developed an unusual "bootstrap" system of pumping liquid propellants for its hydrogen-oxygen engine without using a gas generator.

The P&W *XLR-115* engine, which will power the upper stage of the *Atlas-Centaur* space vehicle, operates its turbopump by harnessing the evaporation of liquid hydrogen used to cool the thrust chamber jacket. Here is how it works:

Liquid hydrogen enters the cooling jacket at a temperature of —423°F. Hydrogen and oxygen burn inside the thrust chamber at 5500°F. The hydrogen in the cooling jacket picks up heat and boils. It then flows into a turbine that furnishes power to pump more liquid hydrogen and LOX into the system.

The fuel thus plays three roles: cooling the thrust chamber, driving the pump system and burning in the thrust chamber.

Charles T. Roelke, general manager of P&W's Florida research and development center, said the engine has been tested numerous times at its rated thrust of 15,000 lbs. for several minutes at a time under simulated space conditions. He said the specific impulse has been found to be more than 30% higher than that for conventional kerosene-oxygen engines. There is no technical reason why much larger hydrogen-oxygen engines cannot be built, he added.

The *Centaur* engine will be a combination of two *XRL-115*'s, generating 30,000 lbs. of thrust. Its first use will be atop an *Atlas*. Later, it will be used as third stage of the *Saturn* system.

The P&W report was the second in recent weeks on progress in liquid hydrogen-burning engines. On Nov. 19, **Aerojet-General** said it has developed a pump that makes feasible hydrogen-fueled space engines up to 500,000 lbs. of thrust and could eventually produce thrusts up to 10 million lbs.

Microwave 'Hazards' Are Exaggerated

The misunderstanding concerning biological effects of high power fields has plagued both the military and industry—research is providing the answers . . .

by Charles D. LaFond

WASHINGTON—A greatly exaggerated problem has harassed both the military and industry for the past few years—the hazards to personnel of relatively high-power microwave energy fields. The problem today is not nearly so much the possibility of physiological damage by radio-frequency energy as it is a case of widespread ignorance of the extent of the problem. As is true in most human endeavor, a lack of understanding results in a fear of the unknown.

Before we go farther, let us clear the air of one continuously perpetuated and apparently unsupported belief. According to Col. George M. Knauf, tri-service coordinator of the whole microwave bio-effect program, *there has not been one medically substantiated case of human injury from microwave energy to date.*

Somehow, the problem is too often confused with the dangers of ionizing radiation.

There is no reason to believe that there is any problem connected with r-f energy that is not related to heat. Heat, in turn, is related to the average power emitted by an antenna. Average power then is a function of power density. The amount of power to a unit of area and exposure time are the principal factors in tissue damage. The kind of tissue is another variable.

The fact that system power is on the increase does not mean that power density also rises at the same rate. As power output has increased, so has antenna size—and power density has followed only a slowly rising curve.

For safety's sake, an arbitrary maximum allowable exposure level was established—0.01 watt/cm^2. It has since been determined that this is an absolutely safe power level for personnel.

• **Some danger**—It is true that an element of danger exists for operating personnel in the close vicinity of high-power ionospheric-scatter and radar antenna installations. With paralleled transmitters, some scatter systems produce an average output power in excess of 100 kw. Several defense radar systems put out concentrated beams of 600 kw. Even the relatively low power (10-kw) of some tropospheric-scatter stations can be a problem because of the power concentration radiated from smaller dishes.

But even with our current incomplete knowledge of the problem we know that simple caution and the observance of a few safety principles can insure a relatively harmless working environment. Thus, accidental exposure probably will be the cause of any injuries that may occur today or in the future.

Knowing that the problem will continue, the military services are maintaining intensive research programs. These are not being publicized in an attempt to avoid unrest with operating and maintenance personnel in the field. Cost of the whole program is approximately $300,000 a year.

• **Slow start**—To a small degree, all three military services have been interested in the bio-effects of microwave energy for many years. Support for such research efforts had been very limited. In 1956, the Air Force was given tri-service coordinating responsibility for this area of study. In 1957, the first tri-service conference was held to discuss the then current research efforts, results, and needed research areas.

Following the conference, the program began to really roll. One year later, a second conference was held to bring together members of the military, universities, and industry now involved in the vastly matured effort. By this time, the field of biology, physics, engineering, medicine, and psychology had been integrated into the overall program.

One thing should be remembered when discussing the research efforts of today: Attempts are being made to find out what may lie ahead in time if power outputs continue to increase. Because of this, there is a wide gap between today's power levels and those of the future. The levels used in experiments in the laboratory under test conditions are far greater than the capability of present equipment. Col. Knauf has stated this in another way: "An effect does not become a hazard until man is exposed to such an effect, and with the equipment of today this possibility is remote."

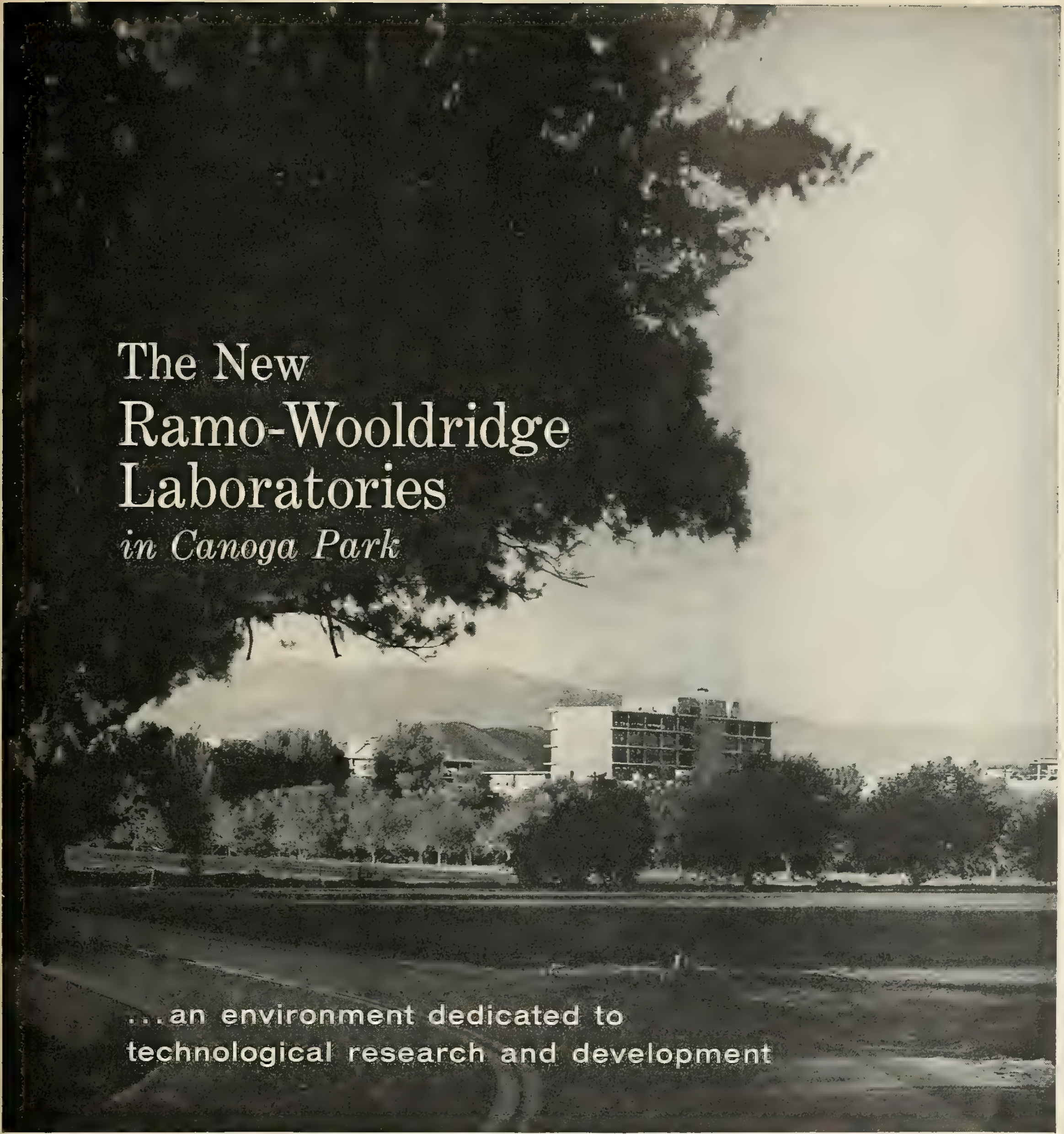
• **R-f effects**—In the electromagnetic spectrum, the microwave region extends roughly from below 1000 to 300,000 mc (30 to 0.01 cm in wavelength). R-f energy has been found to penetrate animal tissue to a depth of from 0.1 to 0.01 the wavelength of the radiation.

The amount of power absorbed by the body varies with the frequency. Above 3000 mc and below about 400 mc, about half of the incident power is absorbed. Total absorbed radiation between 1000 and 3000 mc approaches 100%.

Above 3000 mc, energy produces a considerable rise in surface skin temperature; below 1000 mc, internal heat to a depth of nearly four inches can be developed.

At this time, many feel that sufficient money has been spent in research and that now is the time to provide protection for the very few people who because of their jobs, must expose themselves to higher than safe microwave fluxes.

• **Materials**—A limited effort has gone into the development of protective equipment and shelters. Shielded passageways for example, will be used at the three BMEWS stations. But the


The New
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Laboratories
in Canoga Park
...an environment dedicated to
technological research and development

The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES
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FLOATED RATE INTEGRATING GYROS

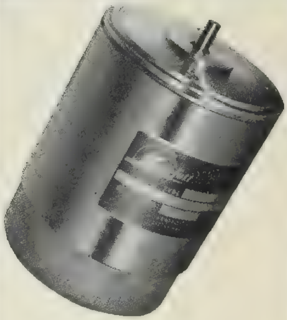
Specifically designed for missile applications, these Kearfott miniature gyros operate efficiently at unlimited altitudes. Their outstanding accuracy and performance make them superior to any comparably-sized units on the market. Hermetically sealed within a thermal jacket, these gyros are ruggedly designed and completely adaptable to production methods. Performance characteristics that are even more precise can be provided within the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
  Along Input Axis: 1.0°/ hr maximum untrimmed
Standard Deviation (short term):
  Azimuth Position: 0.05°/hr
  Vertical Position: 0.03°/hr
Drift Rate Due to Anisoelasticity
  Steady Acceleration: .015°/hr./g² maximum
Vibratory Acceleration: .008°/hr./g² maximum
Damping:
  Ratio of input angle to output angle is 0.2
Characteristic Time: .0035 seconds or less
Weight: 0.7 lbs.
Warm-Up Time: 10 minutes from —60°F
Life: 1000 hours minimum

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



20 SECOND SYNCHRO

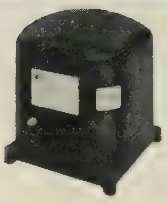
This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

TYPICAL CHARACTERISTICS **SIZE 25**

Type Resolver	Transmitter	Control Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/80°	8500/80°
Secondary Imped.	260/80°	14000/80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



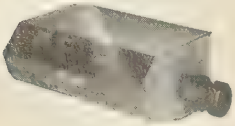
MINIATURE VERTICAL GYRO

Provides accurate vertical reference in the form of two 400 cps synchro signals proportional to sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed and impervious to sand, dust, sun, rain, salt, spray, humidity or fungus as specified in MIL-E-5272A.

TYPICAL CHARACTERISTICS

Free Drift Rate:
  Within 0.5° in one minute time.
Shock:
  The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.
Hermetically Sealed:
  These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.
Operating Temperature Range:
  Gyros operate in ambient temperatures below —20°C to +100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.
Weight:
  5.5 lbs. approximately.

Write for complete data.



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chief method of protection other than this in the future probably will be some type of easily donned apparel.

There are three ways, essentially, of providing protection from microwave incident energy: reflection, absorption, or a combination of the two. Normally, the reflection method would be expected to be cheaper and less bulky.

Several net-like fabrics have been tested successfully although research to date has not been rigorous. One material, worn like a bee-keeper's net from a pith helmet, uses a silver-impregnated nylon thread. Protection is adequate, visibility is not overly impaired, personnel movement is not hindered. Other materials of a similar nature are being tested.

According to Dr. R. W. Wright, Naval Research Laboratory, a resonant transparent shield can be made by modifying the technique used to give low reflections in a bead-supported coaxial line. By using dielectric material ¼ wavelength thick, maximum reflection from a single layer can be achieved. Multiple layers, a half-wavelength apart, will provide greatly increased reflection.

Another easily obtained material for shielding, according to Dr. Wright, is ordinary salt water. Both absorption and reflection can be provided with a relatively narrow layer of the liquid. This could be used as part of a screen room or even in a reflecting suit. Ocular protection without visual impairment would be achieved.

Research at Participating Universities

- **Pennsylvania**—Under the direction of Dr. H. P. Schwan, lab work at the University of Pennsylvania has been directed to the study of microwave absorption characteristics of body tissues. This has been a seven-year program surveying characteristics of various tissue types, including all major types. From data collected over the frequency range of from 40-30,000 mc, Dr. Schwan has drawn several conclusions:

- Dielectric properties vary with types of tissue with extremes provided at one end by the glass body or vitreous humor of the eye (highest) and yellow bone marrow. Properties of the same types of muscle tissue vary within 10% while those of fatty tissue vary by a factor of 5. This has been shown to reflect the variability of water content.

- Frequencies above 3000 mc cause surface heating only. Penetration increases with lower frequencies, particularly below 1000 mc for all tissues.

- Because of standing wave patterns, the use of standard, portable, personnel dosimeters for warning or data indication would be fruitless. For the same reason, energy flux in the body cannot be used as a measure of dosage. Dose or dose rates must refer to the field or flux values in the distant field defined far enough from the body to be affected by its presence.

- **Tufts**—In the Department of Biology at Tufts University, the principal research effort has been the study of microwave energy effects on the human eye. According to Dr. R. L. Carpenter, group director, the fact that lens opacities could result from microwave radiation had been established previously. Thus, for the past three years, his group has performed a detailed study of the conditions under which such cataracts are produced using a specific frequency of 2450 mc.

Time and power threshold exposures, the cumulative effects of repeated subthreshold exposures, and the effects of pulsed-wave versus continuous-wave radiation have been investigated with the following results:

- As might be suspected, the higher power applied, the shorter the time required to develop a lens opacity. More specifically, it was found that the power necessary was inversely proportional to the square root of the time. Power levels from 0.12 to 0.4 w/cm^2 were developed with the exposure periods up to 55 minutes. Six minutes was found to be the minimal exposure period for developing opacity.

- The cataractogenic effect of CW microwave radiation at first appeared to be a thermal effect. A critical temperature was determined to be approximately 50°C. When pulsed-wave radiation was used, the thermal effect was found to be related to average power density of the r-f field. But the relationship of peak power density to opacity was established by virtue of a reduction in the exposure time necessary to develop a cataractogenic effect. This suggests then that the thermal effect is not primarily the cause of lens opacity.

- Repeated exposure at individual time periods of 5 minutes or less did produce opacities and thus there exists a cumulative effect. It is not yet known what time interval is required to prevent a cumulative effect.

- **St. Louis**—Primarily employing a test frequency of 2450 mc in its studies, the St. Louis University's School of Medicine has been investigating a variety of test subjects—tissue from various animal organs and limbs, chicken eggs, vegetable seeds, and whole body tests on rats.

Dr. A. W. Richardson, who leads the research group, has had notable success in developing the Richardson dosimeter. This is a small, portable, low-cost unit that uses a gelatin mass (simulating an avascular body structure) and a thermistor-amplifier-meter arrangement to indicate temperature change in an electromagnetic field. A prototype has been tested aboard the U.S.S. Forrestal (by Dr. T. S. Ely, Office Naval Research) and although it performed reasonably well in indicating the existence of a relatively high r-f field, it also had certain shortcomings. These Dr. Richardson believes will be modified to improve performance.

Experiments by the Richardson group have included high-power-level exposure and long-time exposure extended to terminal death in rats. Considering the limited data obtained in these tests, the group has determined that excessive microwave exposure effects may be more complex than previously believed, and continued research is necessary.

- **Rochester**—The Medical Div. of the University of Rochester has maintained a cooperative effort with the Air Force in studying whole body bio-effects of microwave energy on dogs. Primary aim has been to establish a safe exposure level for personnel working with microwave sources. It has used a radar set (AN/MPS-14) operating at a frequency of 2800 mc with an average power of approximately 2 kw. Pulse emission (2-μsec pulse width, 360/sec repetition freq.) was employed and power densities used in the test chamber varied from 0.05 to 1.2 watts/cm^2 depending on the subject location from the antenna. Exposure periods were 60, 90, 120 minutes.

Preliminary results obtained in the highly controlled experiments have indicated thermal body effects only, and these have been transient with complete recovery following exposure. No residual effects have been demonstrated.

- **Buffalo**—Studies of bio-effects of a 200-mc frequency were performed by the University of Buffalo. Two transmitters were used: one a pulse type providing a low peak power density of 0.045 watt/cm^2 (too low for thermal effect but suitable for athermal study); the other a continuous wave type producing an average power density of from 0.015 to 0.6w/cm^2, depending on distance from the antenna.

Extremely varied repetitive exposures for different test groups were employed over long periods of total time. Test subjects were mice and guinea pigs.

Results: no evidence of lens changes in any of the animals as a result of microwave exposure.

More recent tests with a cw transmitter providing average power densities from 0.04 to 0.6 w/cm² and different time periods of up to 4 hours have provided similar results. Only an increase in body temperatures was noted. Really long-term effects have not been evaluated.

Limited tests using larger animals showed only an increase in body temperatures—no athermal effects.

- **Tulane**—For the Navy, Tulane University has been broadly investigating the effects of 3000-mc and 10,000-mc microwave energy on mice.

Using a wide variety of dosages, researchers noted no significant change in body tissue as a result of microwave exposure.

At 10,000 mc and average powers of 0.02 and 0.06 w/cm², two groups of mice were exposed once for over 3 minutes. Both groups showed first a growth rate retardation, then a marked acceleration which surpassed non-exposed control groups. (The lower power was considered to produce no thermal effect.) Because of the similarity in results, it appears that the effect is not related solely to either heat rise or magnitude of exposure.

Similar growth was obtained at 3000 mc and multiple exposures, but multiple exposure at 10,000 mc resulted in progressive weight loss. Studies are continuing to determine further the mechanics of exposure effects on cells.

- **Miami**—Employing a frequency of 2400 mc, researchers at the University of Miami have done considerable work in studying lethal microwave dosages and exposure times on rats. Most experiments were on the whole body in fields having power densities from 0.020 to 0.26 w/cm² and time periods from 4 to over 480 minutes.

Principal aim was the establishment of minimum lethal dosage times at different power levels. Thus, at one extreme, minimum lethal exposure time proved to be only 4 minutes in the "near zone" when power density exceeded 0.3 w/cm². On the low-power-level end of the scale, minimum lethal exposure time at 0.028 w/cm² was 139 minutes. Below this level and at considerably larger exposure periods, the subjects survived. One conclusion seems fairly evident: minimum exposure time increases almost logarithmically as power level is decreased.

- **California**—Using radiation fluxes from 0.05 to 0.5 w/cm² at a frequency of 10,000 mc, a University of California research team has been studying internal temperature rise and tolerance levels in mice. Results so far are comparable to those described above.

- **Iowa**—The University of Iowa is a pioneer in the field of microwave bio-effect studies. Its first program was maintained from 1946 to 1949. These early tests proved the damage potential of high-intensity exposure to both local tissue and the whole body.

The group currently is studying these effects on the organs of the hollow viscera (using freq. of 2500 mc).

No results so far indicate other than thermal effects as a cause of damage.

- **Southwest Research Institute**—SRI has been investigating the feasibility of using the "electron paramagnetic resonance" technique to determine lens change in the eye of a rabbit. Preliminary experimentation has shown the study to be promising; research will continue.

T. I. Transponder System Used to Track *Thor-Able*

DALLAS—The use of an all solid-state, 440-mc beacon transponder system to track a *Thor-Able* missile was announced recently by **Texas Instruments, Inc.**

Installed in the missile used for project *Transit* (navigational satellite which failed to achieve orbit on Sept. 17), the beacon transponder system responded from 1300 miles in space to an MIT Lincoln Laboratory radar antenna at Millstone Hill, Mass. The system tracked the missile from horizon to horizon during 14 minutes of its flight.

Reportedly, this marked the first time that the Millstone station has been used successfully beyond skin-tracking ranges. The radar-beacon transponder combination is believed capable of tracking distances much greater than the 1300 miles achieved in the Sept. 17th attempt, according to T. I.

Based on range information deduced from the transponder's signals, Millstone site personnel were able to predict the missile's final trajectory early in flight without the usual wait for final accumulation and processing of all data from down-range tracking stations.

Developed and built by T. I.'s Apparatus division for **Douglas Aircraft Co.**, the 6.3-lb. system has a total volume of 0.058 cu. ft. and is capable of 40 hours continuous operation on self-contained batteries. A new series of UHF transistors was used to permit complete miniaturization of the transponder.

NBS Improves Accuracy of Attenuator Measurement

BOULDER, COLO.—The National Bureau of Standards Radio Standards Laboratory here has developed a method for calibrating the lower ranges of a microwave variable attenuator to accuracies better than 0.0001 decibel (10 microbels). This accuracy exceeds the precision to which available attenuators can be set and read, and is the most accurate measurement of microwave attenuation yet made by the Bureau.

Dictionary Published By Portuguese Society

LISBON—Centro de Estudos Astronauticos, a member society of the International Astronautical Federation, has published the first Portuguese dictionary of rockets, missiles and astronautics with the corresponding English terms.

According to Director Eurico Fonseca, the society on request will send copies of the dictionary to United States governmental agencies and industries which are interested. The society, which now has over 200 members, recently sponsored two colloquiums—one on lunar rockets and the second on space law.

Self-igniting Combination Fuels Offer Much Promise

BATON ROUGE, LA.—Smaller, more powerful rocket engines may be the result of self-igniting combination fuels containing boron or aluminum.

Dr. H. A. Beatty of the **Ethyl Corp.** told the 15th Southwest Regional Meeting of the American Chemical Society that such fuels can release energy more rapidly than present ones with correspondingly higher heats of combustion and flame speeds.

The scientist said potentialities of these fuels have yet to be exploited.

William A. Bishop of the **Copolymer Rubber and Chemical Corp.** presented the details of a stop-action study of rubber decay during oxidation.

Analysis of the revealed oxidation rates could be a guide to more efficient rubber-based propellants.

Bishop's method involves the recording of "slow motion explosions" with a high-speed infrared technique.

Making a Spaceworthy Magnetometer

Arnoux Corp. has in prototype stage a device which should meet the low weight, small size and other demands of missiles and small space vehicles

Los Angeles—If a magnetic sensing device is to be incorporated into a missile or a small space vehicle, low weight and small size are prime requisites. Other desirable properties would include capability of detecting very small magnetic anomalies of one gamma or less (1 gamma = 10^{-5} gauss), simplicity in design and circuitry, low power consumption, and the presentation of the obtained data in the form of a continuous signal of suitable amplitude to be fed directly into telemetry systems or recording devices.

A magnetometer which should meet the above requirements is being investigated by the **Arnoux Corporation of Los Angeles.** The device, which is now in the prototype stage, presents the data either in digital form, as an alternating electric potential whose frequency varies directly and linearly with the polarity and magnitude of an ambient magnetic field, or in analog form as an a-c signal whose phase varies in accordance with the magnetic field.

The device appears suitable to place in missiles or small space vehicles where it can be used to measure not only the magnetic field of the earth and other planetary bodies, but the magnetic fields associated with currents moving through the ionosphere and the magnetic fields in deep space, due to streams of charged particles emanating from the sun, or other extra-systemic sources.

In the digital mode of operation, the direct output from the magnetic sensing head consists of an a-c potential of about 1 volt peak amplitude (whose frequency may be pre-determined within very wide limits by circuit considerations), and which may lie between several hundreds of cycles per second and several hundreds of kilocycles per second.

A typical experimental model, now operating in Arnoux laboratories, exhibits these characteristics:

Sensitivity, as determined by deviation from a center operating frequency, is 250% per gauss, or 2.5 parts in 10^5 per gamma.

The dynamic range, over which there is a linear relationship between frequency and magnetic field strength, is approximately ±0.3 gauss (30,000 gammas). However, this range may be extended to several gauss, provided that lower sensitivities can be tolerated.

Operating at a sensitivity of 7 parts in 10^6 per gamma, the dynamic operating range becomes ±1.0 gauss.

The same instrument, operating in the analog mode, exhibits a sensitivity of approximately ±4° of phase per gamma, with a dynamic range of not more than ±20 gammas.

Although these performance figures are typical, digital operation has been obtained, under laboratory conditions rather than operational conditions, with sensitivities approaching 1 part per 10^4 per gamma. Conversely, it is possible to reduce the sensitivity to about 1 part per 10^6 per gamma, with a correspondingly greater operating range, i.e. ±4 gauss.

It has not been found possible to date to operate this type of magnetic sensing head over wider ranges of magnetic field strength and presently it cannot be used for measuring high field strengths.

• **Up to hundreds of Kc**—Although the model under investigation operates in the comparatively low-frequency range (approximately 1000 cycles per second), the device can be made to function up to several hundreds of kilocycles per second. Accurate determination of the frequency may be carried out by a modified counter or period meter.

Excluding whatever method may be used for determining the frequency, or any recording or telemetry equipment, the total power consumption of the device is only 0.8 watts, which may be supplied from a stable source giving 4 volts d-c at 200 milliamperes.

The size and weight of the actual sensing head may be very small—approximately 4 cubic inches and 8 oz. The associated circuitry reportedly is so simple that the device is practically fool-proof. It is envisaged that a cost figure of less than $100 can be reached under production conditions.

Although there are other types of magnetic sensing devices available, which produce a frequency proportional to the magnetic field strength, such as the proton resonance and electron resonance magnetometers, these devices require a considerable amount of power, and in the former case, does not generate a continuous signal.

• **Drawbacks**—Both suffer from the disadvantages of delivering a low amplitude signal, necessitating amplification, and of being unable to produce a coherent signal when operated in the neighborhood of steep magnetic gradients. For instance, it is found that difficulties arise in the proton magnetometer when the gradient exceeds 20 gammas per foot.

Unlike the above magnetometers, which measure total field strength, the device is cosine directional and may be used to measure individual components of the magnetic field.

Essentially, it is a modified magnetron operating under rather unusual conditions. It is not novel to use a magnetron for the measurement of magnetic fields, and several schemes have been put forward, using both the static and dynamic characteristics of magnetrons, which include the measurement of the cyclotron frequency (as a dynamic method) and the determination of the cut-off point (as a static method).

Neither of these methods have proven successful in operational usage, since many factors contribute to the

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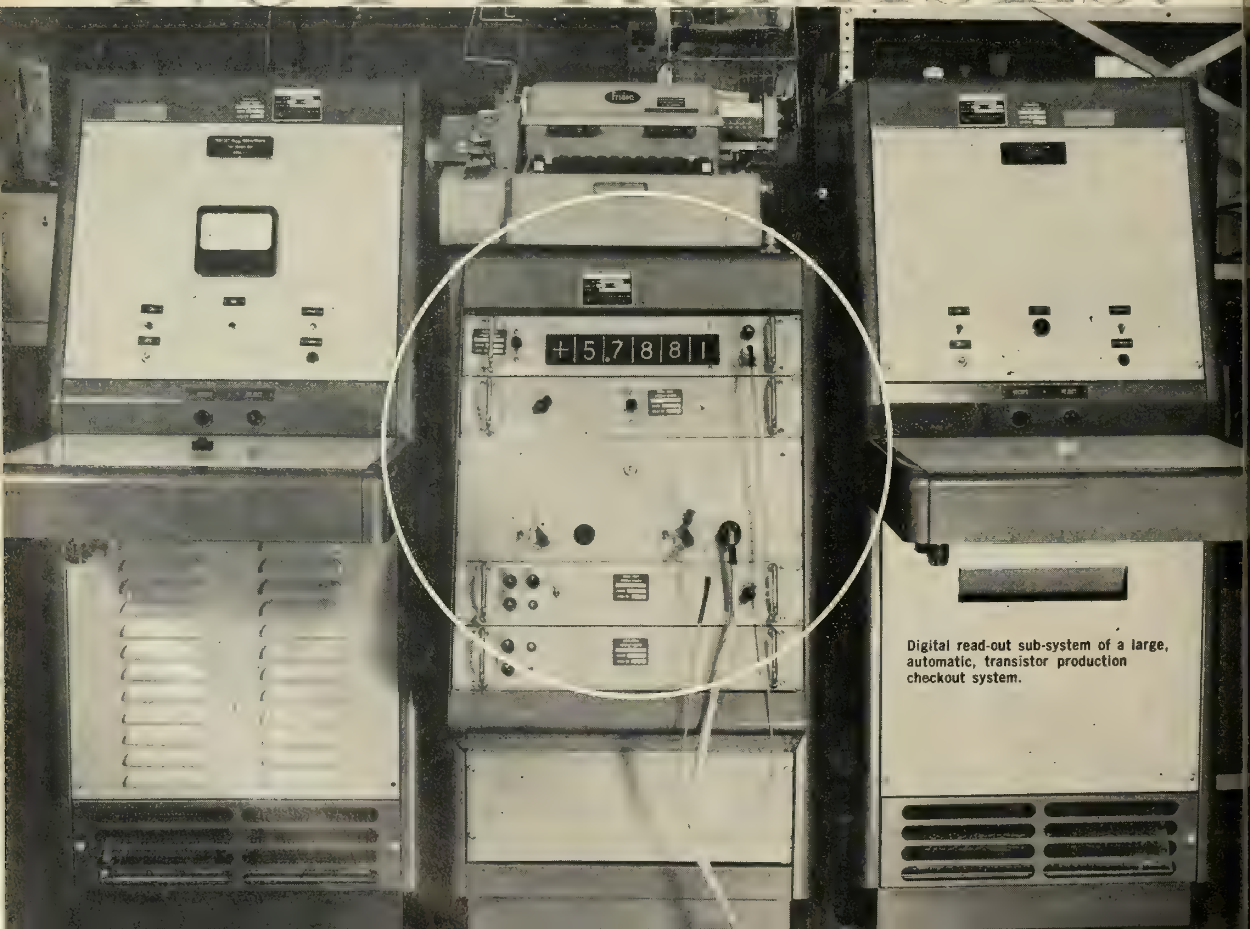
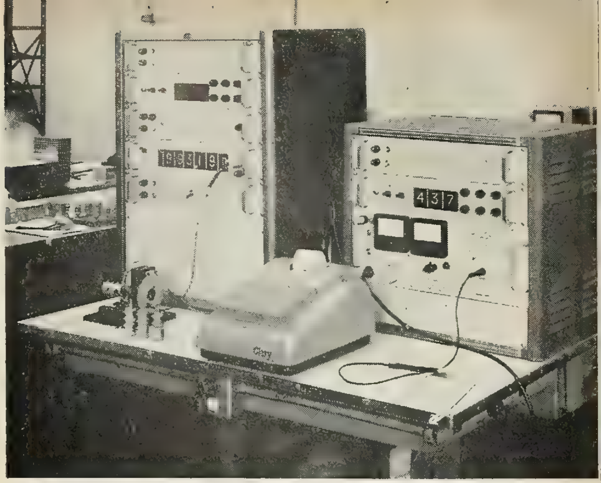


Digital read-out sub-system of a large, automatic, transistor production checkout system.

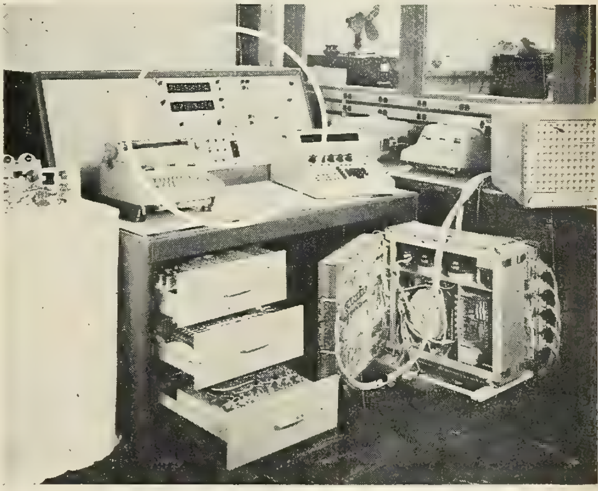
Sub-system for the ground support equipment on the B-58 **Hustler** program. Measures AC and DC single-ended voltages and ratios, and AC and DC differential voltages and transients. Chosen for its excellent operating characteristics under adverse environments.



Resistance measuring system — Used as a secondary standard to make accurate, resistance measurements required for checking linearity of multi-turn potentiometers.

Systems shown here are typical of more than 200 designed and built by EI and now in use. They range in complexity from data logging systems for automatic scanning, measurement and recording of data from multiple transducers... to high speed, automatic checkout systems for missile and aircraft... to systems for automating industrial processes.

Because of the EI modular design approach, many of these systems can be delivered on virtually an off-the-shelf basis, eliminating the long delivery times usually associated with system development. This approach also results in a low cost system because the modules are manufactured in large quantities. Cost is almost a linear function of performance capabilities desired.



Multi-purpose digital measuring and recording system measures AC volts, DC volts, ohms and ratios. Prints and punches information for immediate reading by the operator and subsequent data reduction.

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AC and DC voltages, AC and DC voltage ratios, ohmic resistances, capacitance, frequency, phase, inductance, time, or combinations of these basic input quantities can be accepted by the EI system.

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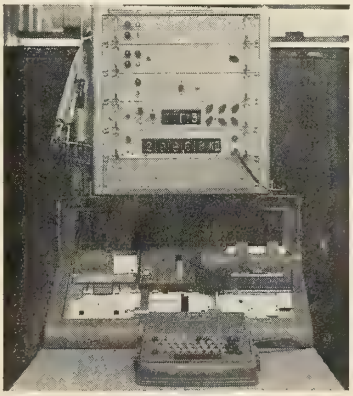
Maximum use is made of solid-state and MIL-type components which are designed into conservatively-rated, field-proven circuits. All vendor-supplied parts are exhaustively tested and evaluated.

MORE FLEXIBILITY

Expansion of the EI system can be made by simply adding appropriate new modules. This approach eliminates new engineering development costs each time needs change; minimizes system obsolescence.

Why not talk over your digital system requirements with your EI Sales Engineer? His system experience will be a valuable help in solving your problem.



Resistor scanning unit — Scans large numbers of resistors, measures values from 0.1% to 0.01% and records the information on punched cards. Operation is automatic and operates entirely unattended.

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determination of the cut-off point other than the theoretical considerations of electron velocities and strength of the magnetic field at right angles to the direction of electron propagation.

Theoretically this "cut-off" should be extremely sharp, provided that the electrons have a singular velocity and that an ideally symmetrical structure is obtainable. In practice, however, the required geometrical symmetry of the magnetron structure, and the perfect axial alignment of the applied magnetic field, is not possible. Further, the accelerating potential and the polarizing magnetic field must be kept extremely constant.

Net result is that the cut-off point no longer becomes clearly defined and exhibits a measurable slope. An added complication is that oscillations may take place in the region of the cut-off which increase the cut-off broadness.

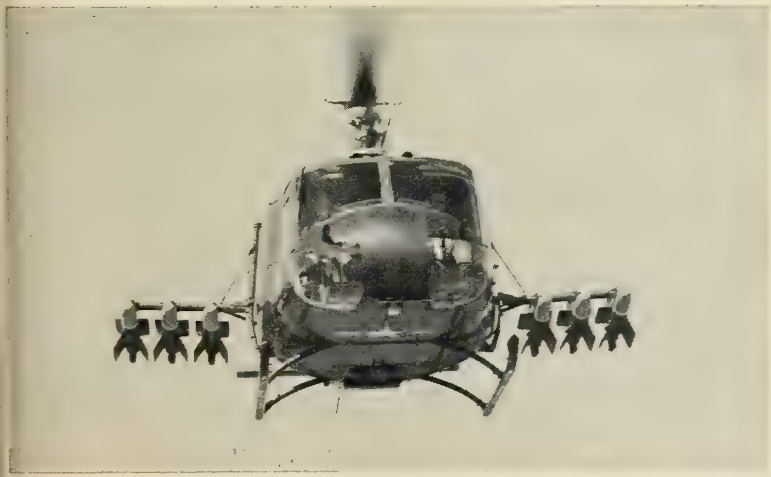
When the collector potential, which accelerates the electrons, is reduced to a very low value, or zero, it may be seen that the cut-off becomes impossibly broad, since the electrons no longer have a singular velocity, being emitted with a wide distribution of initial velocities. Thus the static cut-off method cannot be used with any degree of accuracy.

Early in magnetron development it was found that if the surrounding collector cylinder was split into two semi-cylindrical segments it was possible to generate oscillations in an inductive and capacitative circuit connected between the two segments due to the formation of a negative resistance characteristic. The frequency of this oscillation was determined primarily by the parameters of the external circuit and only to a very slight degree, if any, by the magnetic field strength or collector potential, and this mode of magnetron operation could not be used to measure ambient magnetic fields.

- **Combines principles**—This device, however, makes use of both the principle of self-oscillation by negative resistance, and the broadening of the cut-off point encountered when the collector potential is reduced to vanishingly small values.

Basically, the device creates a "dynamic capacitance" whose value is dependent on the magnetic field strength. Over the oscillating range it is found that, with suitable circuit parameters and suitable magnetron design, the frequency will vary directly and linearly with the applied magnetic field strength.

Iroquois Packs Six *SS-11's*



by an M/R Correspondent

Fort Worth—"The slickest ever." This is what the Army calls **Bell's** new missile-carrying HU-1A Iroquois.

Now undergoing tests at the Army Aviation Center at Fort Rucker and Redstone Arsenal, the turbine-driven craft packs a punch of six **Nord** *SS-11* missiles.

The French-built weapon is a self-propelled, remote-controlled rocket weighing 62.83 pounds. It's 45.91 inches long and is controlled in flight to the target by the helicopter copilot-gunner.

The missile, using solid propellant, can carry antitank, antipersonnel, smoke or inert warheads, used in practice. The rocket builds up to a speed of 600 feet per second or about 410 miles per hour. With a range of more than 3500 yards, it can be fired by a regular 28-volt aircraft battery.

The missiles are attached to the helicopter on 30-inch racks connected to six-foot outriggers on each side of the fuselage. After the missile's impact, a green plastic assembly package drops off with the wire connection that guides the weapon.

The vital mechanisms in the system consist of three explosive bolts.

Bolt number one fires automatically in this manner: the copilot presses the firing button, exploding the bolt. This causes the arm holding the missile to kick up and get out of the way. The upflinging arm depresses a microswitch which fires up the propellant.

Bolt number two drops the plastic box containing the guiding wire. This one is fired manually by the copilot.

Bolt number three holds the entire assembly. The firing of this one allows the whole assembly, racks and all if necessary, to be jettisoned. The third bolt is also fired manually.

The missile assembly is furnished by Nord and is adapted to the helicopter by Bell. Project engineer for the adaptation is W. L. Cresap.

Bell built the outriggers and ran the wiring to them for the control system.

The HU-1A has a 480-pound turbine engine which can develop 860 shaft horsepower and pull the new missile platform along at 125 miles per hour.

The Army, at least for the present, doesn't foresee the helicopter as a direct counterweapon to tanks. The added firepower, rather, will enable it to carry out its original missions of reconnaissance, medical assistance and general troop support.

Guerrilla-style, the 'copter will use its mobility to pop up behind cover, fire and vanish.

Lab Curiosity May Be Useful in Rocket Work

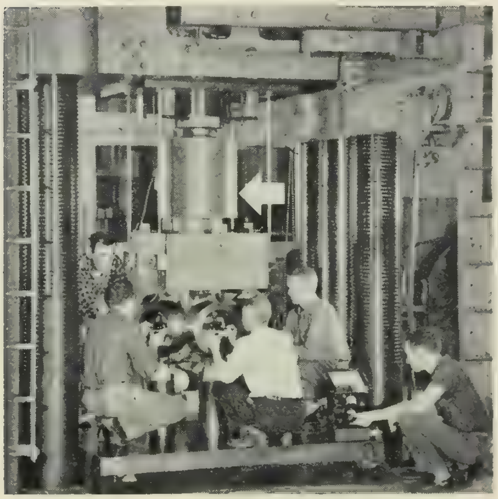
Portland, Maine—A laboratory curiosity which may have some application in rocket technology was revealed by Dr. Jerome R. Tichy of the **Maine Medical Center.**

While investigating reactions between ammonia and phosphorus pentachloride, Dr. Tichy obtained an explosively exothermic result when he substituted urea for the ammonia, in a solid mixture, and applied gentle heat.

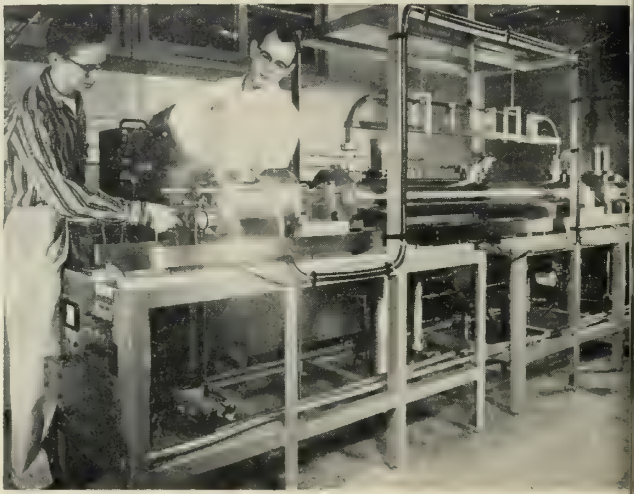
Approximately 50% of the products were gases and, depending on the reactant ratio, the residue was either a dense white solid stable to 360°C, or a sticky, water-soluble liquid. The liquid acts as a glass adhesive when heated.

From a chemical viewpoint, the reaction is extremely complex, involving an unexplained loss of some phosphorus, carbon, hydrogen and chloride.

NBS Needs Funds to Improve Services



USE OF present equipment degrades accuracy. Here a 1.5-million-lbs. load cell is measured with five previously calibrated 300,000-lb. proving rings.



BUREAU'S cesium beam frequency standard is used to check accurac of other types of atomic clocks. Ultraprecise time (or frequency measurements are demanded in space-time relativistic clock tests

by Hal Gettings

WASHINGTON—Demands for extreme accuracy and reliability in missile and space programs is putting an almost intolerable burden on present methods of calibration and measurement.

These requirements cover a fantastic range—from an accurate measurement of one millionth of an inch up to the measurement of two million pounds of thrust. And adequate measurement standards to cover these requirements are just not available. The lack is seriously hampering missile and space programs and is causing widespread concern among those connected with these programs.

Our one source of basic calibration measurements is the National Bureau of Standards. But even the Bureau doesn't have the facilities and equipment to meet new demands. Only recently were they able to devise a technique for measuring the required one-millionth-inch accuracy of standard gauge blocks, and this only on a complicated laboratory basis. Efforts are under way, however, to expand the services offered by the Bureau and to be able to offer the services demanded by new technology. Here, as in many other places, there's a lag between the job needed and the money necessary to do the job.

Last year the Bureau's budget was around $35 million. Of this amount, $15 million was supported by NBS appropriations. The balance came from other Federal research and development programs and services to industry. These services include calibration, testing and the sale of standard materials samples.

The Bureau's Jobs

Briefly, as defined by Congress, the responsibilities of the Bureau are: 1) development and maintenance of national standards of measurement and provision of means for making measurements consistent with these standards; 2) determination of physical constants and properties of materials; 3) development of methods of testing materials, mechanisms and structures, and the making of such tests; 4) cooperation in the establishment of standard practices; 5) advice to government agencies on scientific and technical problems, and 6) invention and development of devices to serve special needs of the government.

Facilities of the Bureau are divided between the primary laboratories and headquarters in Washington, and the laboratories at Boulder, Colo. Plan have been approved by Congress for new facility at Gaithersburg, Md. Bu to date only $4 million of the necessary $90 million for the facility ha been appropriated. Design is near completion and Bureau officials are urgin a go-ahead on construction. Two o the main features and most urgen building needs are a force-measurin installation far beyond that presentl available in the Washington lab, an construction of a linear accelerator.

Bureau of Standards services cu across almost all fields concerned i the missile and space business. The include, generally, electricity and electronics, optics and meteorology, hea atomic and radiation physics, mechanics, radio standards, metallurgy an materials, and chemistry.

As mentioned before, one of th top priority items for the Bureau the expansion of deadweight testin facilities. Such facilities are particularl vital in missile/space vehicle development and are absolutely necessary t calibrate force-measuring devices t the required accuracies. During 195 900 such calibrations were made.

Present capability is limited to machine of 111,000 lbs. New design

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on the board for the Gaithersburg facility will include machines with 300,000 and 1 million lb. capacity.

Indicative of the need for a new super-heavyweight machine, the Bureau has just completed tests on a 1.5 million pound load cell for **Rocketdyne** which will be used in thrust-measurement tests of large rocket engines. A 2-million-lb. cell is presently under construction and this, of course, will have to be calibrated.

Present techniques without the facilities needed involve a complicated process of calibrating proving rings and using these in turn for the final calibration. Consequently several steps are involved with a significant loss of accuracy in each step. Load cells of 3-million-lb. capacity are now calibrated to an accuracy of 0.4% in a compression machine. This accuracy, however, is not sufficient for the missile/space industry.

Industrial weighings require accuracies of 0.05 to 0.2%, and accuracies of 0.1% or better are needed for measuring thrusts of large rocket engines. Calibration accuracies with the new machines should be well within these requirements.

During Fiscal 1959 the Bureau provided 65,401 separate calibration services. These provided an income of over $1.25 million. During the same period, they tested 61,000 samples of materials and devices, the value of which amounted to $1,378,000. The Bureau also sold a wide range of samples ranging from resolution test charts for optics to uranium isotopes standards. The value of these samples was approximately $300,000. (More than 550 different standards of metals, ores, ceramics, chemicals, and hydrocarbons are available for distribution.)

- **Atomic and radiation physics**—The Bureau has been under an ever-increasing demand for services and information relating to atomic and nuclear physics. To meet these needs, research, development, and standardization programs are carried out on a wide scale. This work includes spectroscopic research, free-radicals studies, semiconductor analysis (M/R, April 27, 1959) and many other aspects of the behavior of electron particles and radiation.

- **Chemistry**—NBS does extensive work in both basic and applied research in chemistry as applied to the missile field, most importantly in materials research. Work has included research on alloys, boron compounds as potential fuels, and plasma jet studies.

- **Development, improvement and maintenance of standards and the measurement of mechanical quantities**—Basic to the Bureau's program. Some areas here relating to the missile/space business include calibration of high-acceleration vibration pickups, the setting of standards for magnetic tapes used in recording telemetered data from missiles and satellites, pressure measurements, and performance testing of telemetering transducers.

The Bureau has done both fundamental and applied research on a wide variety of materials vital to missiles and space. One area of attention has been ferroelectrics which are used in accelerometers, as dielectrics, and as memory devices in electronic computers. Extensive work has been done also in ceramic dielectrics. Further work in this area has included high-temperature coatings for supersonic vehicles.

- **Data-processing systems**—The Bureau has provided research, development, systems design, and analysis as well as technical advisory services, for both digital and analog computer technology. This has included work on high-speed automatic data processing systems and processors, analog computers, and considerable work on the computer components techniques—as well as on core circuitry, rapid access, digital systems, and advanced computer simulation systems.

- **High-pressure standards**—The pressure standards program has been recently expanded to include development of improved standards and techniques for measuring very high pressures. Extreme pressures offer great promise in treating new materials to meet some of the most severe military and industrial requirements. Remarkable changes in physical properties often appear when materials are subjected to high pressures. Some familiar electrical insulators become semiconductors, and some familiar semiconductors become conductors. Experiments have been conducted at pressures up to almost 2,000,000 psi.

- **Cryogenic engineering**—The Bureau's cryogenic engineering program is located at the Boulder laboratories. Research in this area is particularly vital to the missile industry, not only in the production and handling of cryogenic fuels, but also research into the behaviour of materials at extremely cold temperatures. The Boulder cryogenic facility's basic function is to acquire and disseminate basic engineering data on materials, processes and equipment used at temperatures as low as −456°.

- **Standards and calibration in radio and electronics**—Space exploration, automation, and miniaturization are subjecting electronic equipment to new and complex uses as well as to extreme environments where the need for accuracy and reliability becomes increasingly important. In the missile field, for example, it is estimated that reliability above 90% can be achieved only if each component has not more than 1 to 1000 probability of failure. To produce components with the necessary uniformity and accuracy requires a chain of calibration leading from the assembly line back ultimately to NBS's precise electrical standards.

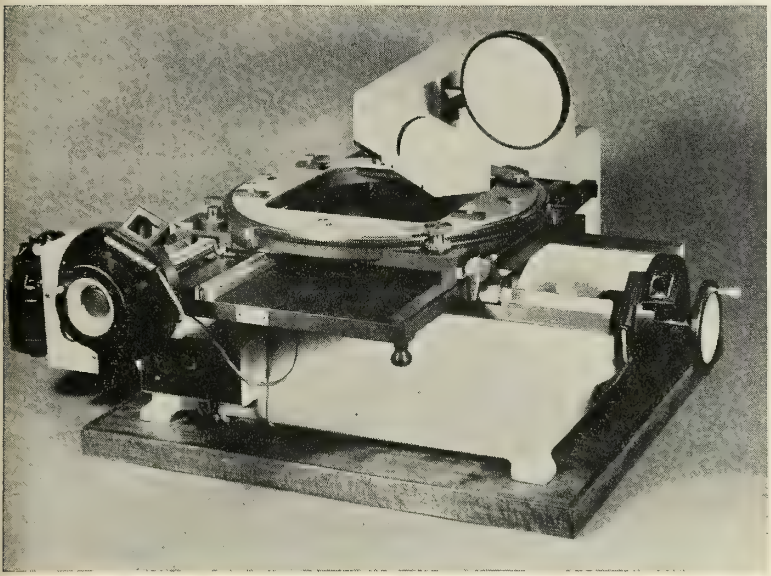
As indicated by a recent Aerospace Industries Association survey, the precision needs of the military services and industry are outstripping the availability of standards and calibration services in the radio-electronics field. Manufacturers have attempted to fill the gap by calibrating their own working standards, but these lose much of their value if they are not calibrated in terms of national standards.

The Bureau's Radio Standards Laboratory at Boulder is expanding its program of standards research and calibration services to provide standards measurement techniques and associated instrumentation needed for all radio frequency and microwave quantities.

At present, standards are being established or improved for frequency, power, attenuation, voltage, noise, field strength, interference, conductivity, dielectrics and magnetics. In addition, a new laboratory using advanced techniques, has recently been activated to study radio properties of materials. (A survey of RSL work was carried in the Nov. 17, 1958, issue of M/R.)

One of the primary functions of the Boulder lab is work in radio propagation. This includes work on finding the origin and structure of the ionosphere and its influence on radio communication, and the propagation of low and very low frequencies over the earth and through the upper atmosphere. They operate here a radio "weather" service which issues predictions for optimum frequencies for radio transmissions, and forecasts radio transmission disturbances. From this work comes information that assists government agencies in allocating frequency spectrum assignments on the most efficient basis. Another service of RSL is the monitoring of radio-standard frequencies with atomic standards making comparisons to one part in 100 billion.

Far more than merely establishing basic standards, Bureau activities have contributed directly to many aspects of our missile and space programs. Even greater returns can be reasonably expected with increased support from government and industry.



Satellite Orbits Plotted by Comparator

A two-coordinate precision screw comparator called Model 422D specifically designed to facilitate operator handling and to give extreme versatility in use is announced by **David W. Mann, Inc.**

Applications of Model 422D are exceptionally varied, ranging from medical, chemical and ballistics research to the study of survey and space measurements. The Smithsonian Astrophysical Laboratory used it to plot the path of *Sputnik I* and *Explorer I* when the satellites first went into orbit. It was also used in Project *Vanguard* to calibrate the Minitrack system.

The two coordinate comparator accomodates plates and films to 10" x 10" with a measurable area of 9" x 9". It has a range of 265 mm in the X-Coordinate and 250 mm in the Y-Coordinate. Illuminated dial units provide direct reading accuracy to one micron in both coordinates.

Offering operator convenience, a unique two-stage projection system combines plate image with measuring mark, projecting it on a screen at 22X magnification. The top stage rotates through 360° with vernier readings on the precision circle to 20 seconds. The front surface projection system produces large clear images, reducing error and fatigue.

The operator is provided with the added convenience of direct viewing without the confining position of direct viewing systems. Slides may be moved by precision screws or disconnected and actuated freely for quick alignment of widely separated points.

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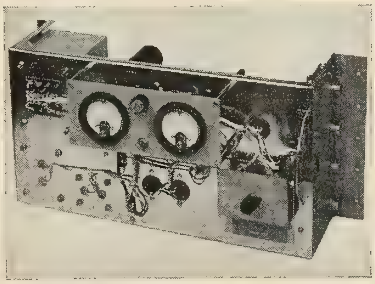
Transistor Power Supply Has Low Thermal Drift

A transistorized, regulated power supply, Model PS4023, is available from **Power Sources, Inc.**

Operating at an input voltage of 105-125 volts at 57-63 or 380-420 cps, it puts out 100 to 200 volts at up to 400 ma load current. The output voltage is selectable by a six-step range switch, while a vernier potentiometer is provided for exact adjustment of output voltage.

Regulation performance is such that there is less than 0.03 percent change in the set output voltage for any combination of input voltage or load current conditions.

Thermal drift is held to a minimum. There is less than 0.006 percent per degree Centigrade change in output voltage. Total ripple and noise is less than 2.5 rms millivolts.



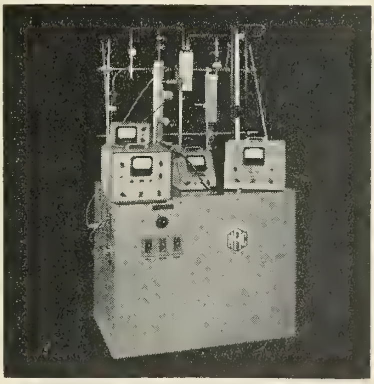
Recovery time with the vernier set at the low end of the range is 20 milliseconds, while with the vernier at the high end, recovery time is only 150 ms. Special circuitry prevents damage to components when the output is dead shorted.

Circle No. 226 on Subscriber Service Card.

Test Bench Simplifies Vacuum Gauge Calibration

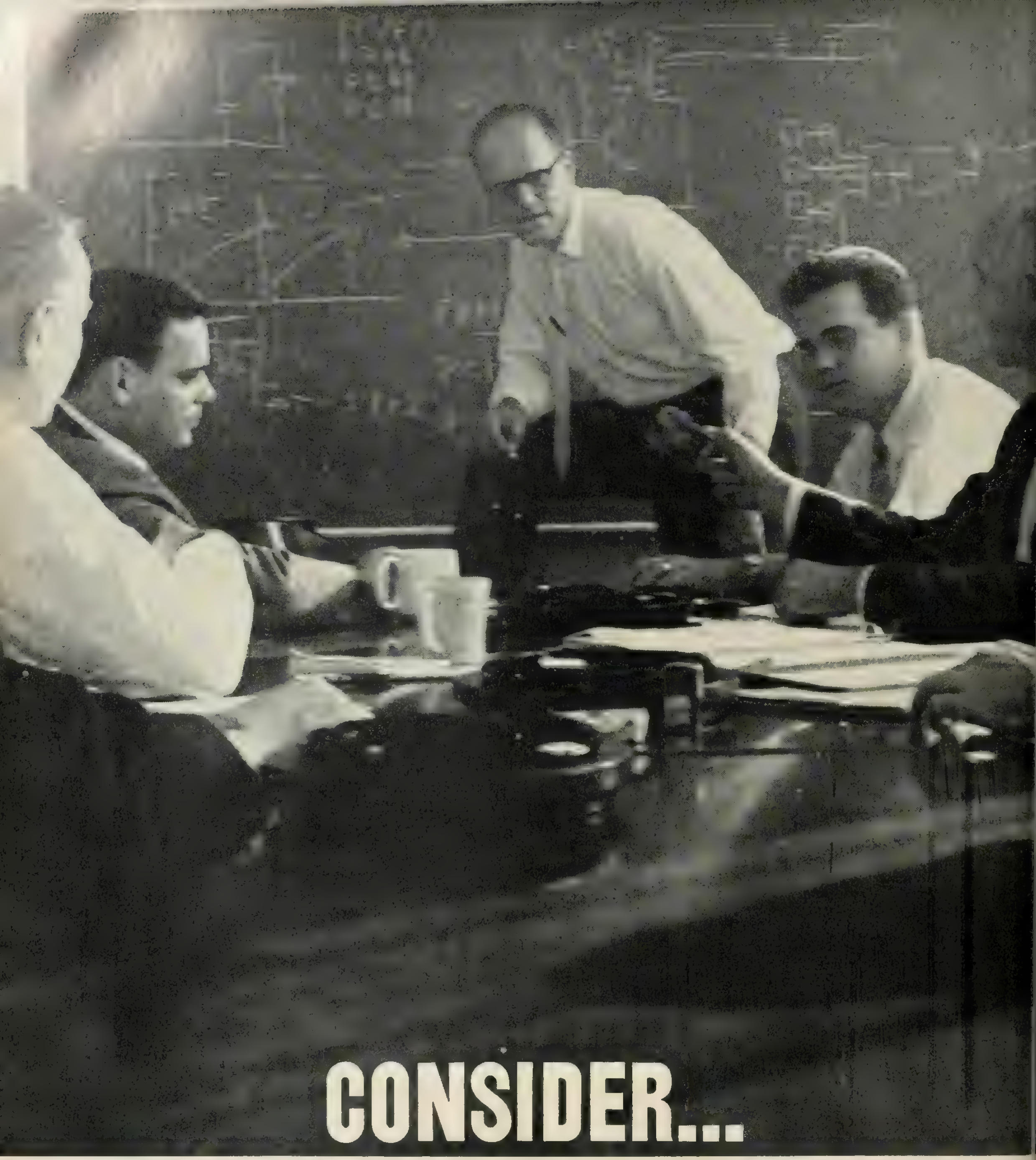
A universal test bench that can be used to calibrate vacuum gauges with ranges from atmosphere down to as low as 10^{-5} mm Hg. pressure has been developed by **NRC Equipment Corp.** for use in industrial plants and in industrial, university and military laboratories.

The completely self-contained system is expected to eliminate the problem of shipping gauges back to the manufacturer for calibration and thus to contribute to more accurate control of vacuum processes and research studies.



The apparatus consists of a 2" high vacuum pumping system complete with air drying column, pressure regulating needle valve, and liquid nitrogen traps; a vertical manifold with individually valved gauge ports; a three-range McLeod gauge with associated CO_2 driven mercury system; and a precision manometer. All components are mounted in or supported on a compact cabinet.

The manometer covers the range from atmospheric pressure to 5 mm Hg and can be read to an accuracy of 1 mm Hg or better. The multi-range McLeod gauge, used because of its reported accuracy and stability over long periods, will read from 17 mm Hg to 0.03 microns; ranges are 3.5 to 17 mm



Lockheed for telemetry

Out of Lockheed creative engineering sessions such as this come advanced design and proven performance in the field of telemetry. Lockheed's pioneer work on the X-17 project resulted in the first successful telemetering of vital data during re-entry. Research continues to provide even greater reliability of performance to meet present requirements.

The Lockheed Electronics and Avionics Division (LEAD) is currently conducting research in Frequency Modulated and Pulse Modulated Systems for industrial and military needs.

For proven reliability in telemetry components and systems, consider LEAD.

Look to Lockheed for LEAD*ership in Electronics*

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Hg; 0.815 to 5 mm Hg; 0.264 to 1.59 mm; and 0.03mm to 1.13 mm. It is also available with ranges of from 0.004 to 5 mm Hg.

Accuracy of the McLeod gauge is said to be one percent of scale reading, and both it and the manometer are equipped with mirrors to eliminate parallax.

The unit is shipped partially assembled—all that remains for the operator to do is to connect the glass ware by means of a set of waxed spherical joints. Complete instructions are provided for this, and there is no need for outside field men to be involved in the assembly.

Among the gauges for which the Model 904 is adaptable are thermocouple, thermopile, and Pirani gauges, Phillips and Aphatron Ionization Gauges and, over part of their range, hot wire ionization gauges. It also can be employed for mechanical gauges by use of a pipe adapter in the manifold.

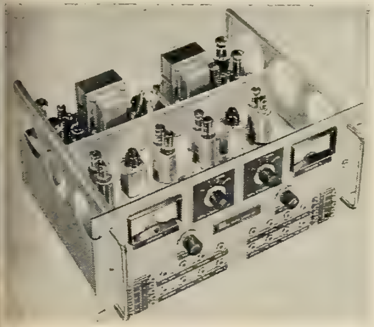
Circle No. 227 on Subscriber Service Card.

Adaptability Features In Servo Controller System

New, high-performance electronic servo-controller combinations for use in dynamic process control systems have been announced by the **Compu-Dyne Corp.**

They are described as the first dynamic feedback control loop components to be developed that easily can be adapted to the individual requirements of practically any given system.

The units, identified as Series 800, can fully reproduce the transfer functions described by a typical, high-grade analog computer. Each unit, comprising a controller, servo-amplifier, and power supply, is capable of performing any of the three basic control functions: summation, integration, and derivative. In addition the equipment is designed so that signals and functions can be added, eliminated, or varied according to the requisites of the system.



The Series 800 Servo-Controller combinations can be applied to the control of any electrically-measurable variable. They are most frequently used with electro-hydraulic actuators, especially where large mass positioning in the final control element is necessary. However, units include provisions for use with electrical and pneumatic actuators.

The three basic sections of each Series 800 unit (controller, servo-amplifier and power supply) are custom assembled according to the demands of the particular system. All units, however, are adaptable to any form of start-up, operational and shut-down programming, and include a mode-selector switch with settings for "automatic," "automatic balance," "manual balance," and "manual." There is provision for individual balancing of each amplifier in multi-amplifier units.

Circle No. 228 on Subscriber Service Card.

Silicon Mesa Transistor In UHF Available

Texas Instruments Inc. has announced that two silicon mesa transistors featuring high power combined with high frequency are available in production quantities.

The new TI silicon mesa transistors, the 2N715 and 2N716, are capable of a guaranteed minimum power output of 500 milliwatts at 70 megacycles. These devices will deliver approximately 50 milliwatts at 200 megacycles. The inherent high-dissipation capabilities of transistors produced by the TI diffusion process permit both the 2N715 and 2N716 to be packaged in the subminiature JEDEC-outline TO-18 case.

Both transistors have a guaranteed beta spread of 10 to 50 and a collector reverse voltage of 50 and 70 volts (for the 2N715 and 2N716 respectively). Collector reverse current at 25°C is 0.5 microamps maximum and 50 microamps maximum at 150 C. Temperature limits are at –65°C and 175°C.

Circle No. 229 on Subscriber Service Card.

Console Interprets Data In Layman's Terms

A control and display console, which enables anyone to operate a computer and which interprets data in nontechnical language has been introduced by the Intellectronics Laboratories of the **Ramo-Wooldridge Division** of **Thompson Ramo-Wooldridge Inc.**

The R-W Analysis Console can be connected to any data processing system. Through the use of a simple keyboard arrangement, operators may control the computer, to which the console is attached, and demand a display of data either in graphic or in understandable printed form on the console's video screens.

This means an individual may search the computer to which the console is connected in his own language, and receive the answer in his own language. It is not necessary to be familiar with the technical computer code.

Circle No. 230 on Subscriber Service Card.

Recorder To Telemeter Manned Satellite

Giannini Controls Corp. announced the development of a new simplified, self-contained inertial platform system for short range ballistic missiles.

This non-servoed system fills the vital requirement for a really small (2¾" dia. x 4½" long), low cost guidance package that will eliminate misalignment and dispersion problems during the high acceleration boost stage of flight.

System components consist of a free gyro and two subminiature accelerometers. The accelerometers are mounted on the gimbals of the gyro with the sensitive axes oriented perpendicular to the gyro spin axis. The gyro spin axis then described the line space along which the rocket is guided. The system is highly accurate and fully operative within 5 seconds after power is applied.

Circle No. 231 on Subscriber Service Card.

Recorder To Telemeter Manned Satellite

A magnetic tape recorder/reproducer built by the DataTape Division of **Consolidated Electrodynamics Corp.** has been delivered to the National Aeronautics and Space Administration to record telemetered data from Project Mercury, the nation's first manned orbital space flight.

The ground recording station is a CEC Type 5-752 Recorder/Reproducer modified to direct record or play back

← Circle No. 10 on Subscriber Service Card.

five channels of analog data, two of FM and two of PDM simultaneously. Special PDM electronics techniques with high accuracy make possible playback at 1-7/8 inches per second. Such accuracy is essential for multiplexed data because of the difficulty of accurate time correlation during reconstruction at faster speeds. The tape transport can also operate at 15 ips.

Circle No. 232 on Subscriber Service Card.

New Literature

MICROWAVE DIODES. A technical booklet on microwave diodes has been made available by **Sylvania Electric Products Inc.** The 12-page booklet contains complete electrical and mechanical data on all microwave diodes manufactured by Sylvania as well as a replacement guide to nearly 200 widely-used diode types.

Circle No. 200 on Subscriber Service Card.

INSULATORS. A revised bulletin on "High Purity Insulators for Sheathed Thermocouples" has been published by **Norton Company.** It describes the uses and technical specifications of fused magnesium oxide, aluminum oxide and zirconis thermocouple tubing used in connection with aircraft turbines, atomic reactors and other situations where accurate temperature measurement is important.

Circle No. 201 on Subscriber Service Card.

CHRONOGRAPH. A two-page bulletin by the **Computer Equipment Corp.** describes the operational characteristics and technical specifications of the Millimicrosecond Quantizer, an electronic chronograph that measures the time between events to a resolution of 20 millimicroseconds with an accuracy of 1 part in 10^7 per day.

Circle No. 202 on Subscriber Service Card.

URETHANE FOAMS. Blowing urethane foams with fluorinated hydrocarbons is presented in a new publication by **Pennsalt Chemicals Corporation.**

Circle No. 203 on Subscriber Service Card.

soviet affairs...

By DR. ALBERT PARRY

Rare-earth elements . . .

as a subject of U.S. Space Age research was one of the less-publicized items on Nikita Khrushchev's list of inquiries during his American trip last September. He did not personally visit the laboratories of the University of Iowa at Ames, whose experiments in rare elements are of such interest to the Soviets. But he did send a metallurgist from his traveling staff, 58-year-old Prof. Vasily S. Yemelyanov of the Soviet Academy of Sciences, head of the USSR Council of Ministers' Main Office for the Utilization of Atomic Energy, to observe the Iowa experiments.

"Most interesting" . . .

were those experiments, the Russian scientist reported one month later in *Izvestia.* In his article Prof. Yemelyanov noted that, for their study of the properties of the elements, the Ames researchers "separate them in their pure form, which then, as a basic element, reaches 99.99 per cent." He praised the special laboratory equipment at Ames which results in the yield "of several tons of rare-earth elements a year." Wistfully he proposed Soviet-American collaboration in this as well as other fields of scientific research.

What rare rocket-age metals . . .

especially interest the Soviets? One answer was given sometime ago in *Komsomolskaya Pravda* by L. Tisov, an engineer and a geologist, who in a detailed article named the following rare and scattered elements which "await their future": Niobium, tantalum, lithium, beryllium, zirconium, boron, germanium, gallium, thallium, and thulium. More recently, in another *Komsomolskaya Pravda* article, A. Presniakov mentioned hafnium among several much-valued metals that some day in the future "may be grown as vegetation." He referred to French research with plants known to accumulate tiny stores of metallic elements in their roots, stems, branches or leaves. Using these French experiments as his base, the Russian author boldly predicted "A Garden of Metals" (the sensational title of his article) where man tomorrow would grow and harvest "not fruit or berries, but metals," particularly such rare ones as hafnium, lithium, and zirconium.

Gallium, meantime, is produced . . .

prosaically, along with other rare metals needed by the Soviets that cannot wait for those fantastic gardens of the future. We read in *Krasnaya Zvezda* that Hungarians are now obtaining gallium, this "extraordinarily rare metal," not from any trees or bushes, but as a by-product of their aluminum industry. Hungarian scientists and engineers are reported by the Red army newspaper to have evolved a new method of treating the remnants of alumina after the latter is processed into aluminum, with the result that the alumina waste yields the greatly desired gallium.

A special gallium factory . . .

has been built in Hungary for this purpose, producing nearly 15 kilograms of gallium annually. Pointing to the high cost of gallium on the world market ("worth more than diamonds"), the Russian military daily says: "The atomic industry is the most important field where gallium finds its application." That the Hungarians are producing gallium for the needs of the Soviet empire, and not for themselves, is quite evident.

A Space Age substance called "sitall" . . .

is announced by Moscow's Tass News Agency as the latest proud achievement of Soviet scientists. A glass microcrystalline material, it is described as lighter than aluminum and more durable than steel. It can stand temperatures of 1000°C (1832°F), and has "high mechanical, thermal and electrical properties."

contracts

NASA

$25,690—ITT Corp., Industrial Products Division, San Fernando, Calif., for oscilloscope display for monitoring tunnel tests.

$25,312—Midwestern Instruments, Tulsa, Okla., for direct recording oscillograph for Lewis Research Center, Cleveland.

NAVY

$500,000—Northeastern Engineering, Inc., Manchester, N.H., for furnishing an undisclosed quantity of high-speed electronic frequency counters, used for missile checkout, for calibrating single side band communications and for similar systems.

$149,008—North American Aviation, Inc., Autonetics Div., Downey, Calif., for design, development and furnishing of two Verdon computers.

$53,303—Commercial Engineering Corp., Houston, for design, development, and construction of one variable depth sonar-towed vehicle.

MISCELLANEOUS

ALWAC Computer Div., El-Tronics, Inc., Hawthorne, Calif., has received a contract from **Marquardt Corp.**, for a special on-line data reduction system. Amount not disclosed.

$400,000—Flite-Tronics, Inc., for design and manufacture of laboratory test equipment. Subcontract from **Hughes Product Div., Hughes Aircraft Corp.**

$392,000—Hoffman Laboratories Div., Hoffman Electronics Corp., for maintenance and operation of TACAN air navigation equipment, ARN-21, and associated equipment.

$270,000—Sylvania Research Laboratories Div., Sylvania Electric Products., Inc., for research and development on high-temperature materials for use in solid-fuel rocket engines.

AIR FORCE

$26,546,250—International Business Machines, for installation, on-site maintenance and logistic support of the computer systems at SAGE sector sites.

$15,000,000—Raytheon Co., Waltham, Mass., for development of a radar system to track intercontinental ballistic missiles thousands of miles away and to identify their warheads.

$6,627,092—Philco Corp., Government & Industrial Div., for engineering, furnishing and installation of equipment for the Quick-Fix phase of AIRCOM integrated communications system.

$4,815,000—Avco-Everett Research Laboratory, a division of Avco Corp., for the continuation of basic studies applicable to ICBM re-entry vehicles, and other classified areas of work.

$3,940,000—Radio Corp. of America, for work on a new Pacific Ocean research center that will seek new ways to detect and identify incoming missile warheads.

$1,250,000—Hughes Aircraft Co., Culver City, Calif., for continued development of AN/ASG-18 fire control system and *GAR-9* air-to-air missile.

$929,210—International Business Machines Corp., for SAGE system engineering program.

$618,835—Columbia University, New York City, for continuation of research on a MASER to amplify or oscillate at infrared frequencies.

$268,928—Collins Radio Co., Cedar Rapids, Iowa, for components of the MA-1 flight director system.

$84,760—Cornell University, Ithaca, N.Y., for continuation of research on new solid defect structures.

$64,798—C. P. Bauman & Son, Champaign, Ill., for modification of building to provide facilities for *GAM-77* training.

$47,400—Johns Hopkins University, Baltimore, for continuation of a "Study of the Spectra of the Triply Charged Rare Earth Ions."

$40,003—Boeing Airplane Co., Pilotless Aircraft Div., Seattle, for reproducible copy applicable to the *IM99A* missile.

$44,000—The Institute of Advanced Study, Princeton, N. J., for continuation of work on "Advanced Mathematical Research."

$39,716—Yale University, New Haven, Conn., for research on "Electron Nuclear Interactions and Related Aspects of Nuclear Structure."

$32,570—Arthur D. Little, Inc., Cambridge, Mass., for performance of research and preparation of reports relating to a space environments simulation facility.

$27,522—Litton Industries, Electronic Equipment Div., Beverly Hills, Calif., for performance of research and preparation of reports relating to a space environments simulation facility.

$25,000—California Institute of Technology, Pasadena, for continuation of research on "Equations for Viscous Fluids."

ARMY

$22,143,981—The Martin K. Eby Construction Co., Wichita, Kan., for *Atlas* missile facility construction at Warren AFB, Cheyenne, Wyo.

$11,889,500—Western Electric Co., for improved capability of the *Nike-Hercules* missile system.

$3,000,000—Western Electric Co., for repair kits for the *Nike-Hercules* missile system.

$2,100,000—Ramo-Wooldridge, Div. of Thompson-Ramo-Wooldridge, Inc., Los Angeles, for automatic data processing system test facility.

$2,050,000—Chrysler Corp., Detroit, for deployment of *Jupiter* missile systems to overseas installations. Two contracts.

$1,722,000—Esso Research and Engineering, Elizabeth, N. J., for continuation of a program of advanced research on solid rocket propellants.

$1,584,555—Varian Associates, Palo Alto, Calif., for tunable high-power klystron tube for the *Nike-Zeus* acquisition radar transmitter and ancillary items.

$1,032,480—Arrow Construction Co., for construction of drone assembly building, Fort Hauachuca, Ariz.

$589,355—Philco Corp., Philadelphia, for basic and logical processor and computers for automatic data processing system.

$550,135—John C. Abbott, Vero Beach, Fla., for construction of Navy Fleet ballistic missile facilities and buildings at Air Force Missile Test Center, Cape Canaveral Missile Test Annex.

$460,000—The Fruehauf Trailer Co., Detroit, for the manufacture of 111 antenna carriers used as part of the ground support equipment for the *Hawk* missile.

$400,000—Langley Corp., for development and production of *Atlas* ground support equipment. Subcontract from **Convair-Astronautics.**

$300,000—Collins Radio Co., Richardson, Tex., for services and materials for one primary and two secondary satellite tracking stations.

$300,000—Radiation, Inc., Melbourne, Fla., for ground stations for *Courier* communication satellite system, satellite checkout facility.

$252,448—Electron Tubes Div. RCA, Harrison, N.J., for services and materials for research and development directed toward fulfillment of SCTR entitled "A Reliable Long Life Pencil Triode for a Communications Satellite."

$129,847—North American Aviation, Missile Division, Downey, Calif., classified.

$71,000—General Electric Co., Syracuse, for repair parts for radar sets.

$57,198—Eitel-McCullough, Inc., San Carlos, Calif., for electron tubes.

$56,150—Collins Radio Co., Cedar Rapids, Iowa, for development of improved tactical antenna system.

$50,000—ITT Labs, Div. ITT Corp., Nutley, N. J., for ground stations for *Courier* communication satellite system.

$49,408—Motorola, Inc., Phoenix, Ariz., for testing AN/MRC-66 automatic electronic switching equipment.

$44,000—Molybdenum Corp. of America, Washington, Pa., for 25,000 lb. molybdenum (contained).

reviews

SOVIET NUCLEAR PROPULSION, Triumph Publishing Company, Washington, D.C. 45pp. $2.85.

This study of Soviet developments in nuclear transportation and propulsion was originally translated from the Russian for U.S. Intelligence purpose.

Published as an aid to U.S. research and development, the pamphlet is a general survey of Soviet proposals and concepts. Partial contents include: "Nuclear Engines," "Nuclear Submersibles," and "Nuclear Rocket Propulsion."

HIGH TEMPERATURE CRITICAL SYSTEMS, Harry L. Reynolds, Lawrence Radiation Laboratory, Livermore, Calif. Order ARS 1014-59 from American Rocket Society, 500 5th Ave., New York 18, N.Y.

Over the past few years, the laboratory has been involved in the measurement of critical masses for "clean" systems at room temperature. A "clean" system is a critical assembly of very simple geometry such as rectangular parallelipiped containing only the fuel and moderating materials.

The moderating materials used in these "clean" experiments were graphite, beryllium, and beryllium oxide; all useful materials for high-temperature propulsion reactors.

Criticality in the Hot Box was attained for the first time in February of this year. The concept of studying "clean" systems has been continued. At the present time, a BeO-moderated, graphite-reflected system is under study. The graphite reflector is maintained at a temperature 800° lower than the BeO core.

SYSTEMS FOR IGNITION OF SOLID PROPELLANTS, J. W. Rabern, Olin Mathieson Chemical Corporation. Order ARS 977-59 from American Rocket Society, 500 5th Ave., New York 18, N.Y.

The design of ignition systems for solid rocket engines is primarily based on empirical approaches and past performances of other ignition systems.

Design problems frequently encountered in ignition programs include: envelope for the ignition, reproducible ignition delays, controlled chamber pressure during ignition, determination of propellant ignitability, ignition of aged propellant, low-temperature ignition without overpressurization of chamber at high temperature, control of debris from inert igniter components, vibration, drop test and autoignition requirements.

The historical development of ignition compositions and of igniter designs is described.

R. F. AMPLIFIERS, Edited by Dr. A. Schure, John F. Rider Publisher, Inc., N.Y., $2.40

Volume 27 of the Electronic Technology Series, this book covers the design and theory of a wide range of both low- and high-power r-f voltage and power amplifiers. It treats all classes of v.t. and transistorized amplifiers and includes practical design examples.

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Santa Monica, Calif.

propulsion engineering...

By JAY HOLMES

A big development contract . . .

in the offing is the half-million-pound-thrust, second-generation liquid hydrogen-LOX engine. NASA is planning to ask for funds in the 1961 budget to start work on the $50-100 million job.

As a result, major rocket companies have begun to make claims and counterclaims about their capability for work with hydrogen, the ultimate chemical fuel. **Pratt & Whitney, Rocketdyne** and **Aerojet** all have made statements recently aimed at calling attention to their qualifications. In addition, **General Electric, Bell Aircraft** and **Thiokol's Reaction Motors** are known to be interested. **Curtiss-Wright** is a seventh possibility.

Performance details are classified . . .

although any engineer with a slide rule could calculate that the optimum thrust for a high-energy second stage atop *Saturn* is between 500,000 and 600,000 lbs. But this doesn't mean that a single chamber of such huge size will be developed.

In all likelihood, the engine will be a cluster. One guess might be a cluster of four in the 125,000-150,000-lb. class. The most commonly mentioned development time is about three years. This would make the hydrogen engine available for housing in a vehicle at about the same time the *Saturn* booster is ready.

The 30% impulse rise . . .

that results from burning hydrogen as a fuel is the basic fact underlying NASA's interest. Substitution of hydrogen for kerosene as fuel in any stage makes possible a 50% increase in payload. Substitute hydrogen in two stages and you more than double the payload.

Surprisingly, materials are less of a problem. The temperature of a hydrogen-oxygen flame is less than 6000°F, more than 200° less than the temperature of an oxygen-RP flame. The added impulse of hydrogen results from the fact that the product molecules, mostly H_2O, are much lighter. Some of the hydrogen isn't burned. Instead of a stoichiometric mixture of 8 parts oxygen to 1 of hydrogen (by weight), the optimum combination is in the range of 5-7/1. The unburned hydrogen, with a molecular weight of 2, thus adds tremendously to the average velocity.

Who's on first in hydrogen engines? . . .

Any list would have to start with Pratt & Whitney, which just last week announced successful tests of the 15,000-lb. *Centaur* engine (see page 19). Pratt & Whitney estimates it has put $8 million of company money into facilities and development, in addition to the government funds it has received through a contract first with the Air Force and now with NASA.

Rocketdyne points out that the biggest engineering problem is the pumps—because the low hydrogen density entails such a large volume of liquid—and that it has built what it calls the biggest liquid hydrogen pump in the free world. Rocketdyne developed the pump for AEC and NASA under the nuclear rocket program. Rocketdyne, which has been working on liquid hydrogen for four years, says it has spent more than $250,000 of its own funds to develop all the components necessary for a big LOX-hydrogen engine, including gas generator, turbines, thrust chamber and controls.

Aerojet cites its experience under an Air Force contract, now phasing out, through which it investigated the feasibility of a hydrogen-burning engine with more than 100,000 lbs. of thrust. Aerojet has fired brief bursts from such an engine, the largest on this side of the Iron Curtain. More than $400,000 of company money has been spent on the Aerojet engine's pump feed and regenerative cooling system.

Why is hydrogen so special for space? . . .

One intriguing advantage is that it could be stored on the moon, where there'd be no problem in maintaining the vacuum necessary for insulation.

Air brake for a spaceliner

The earth's atmosphere, one of the biggest obstacles to getting into outer space, can be one of our biggest assets coming back. At Douglas we are investigating how we can use its braking effects on rockets returning from deep space trips at far faster than ICBM speeds. Success will allow us to increase payloads by reducing the weight of soft landing systems. This technique also will aid us in pinpointing landing areas. Current reports show real progress. Douglas is engaged in intensive research on every aspect of space planning, from environmental conditions on other planets to the destroyer-sized space ships necessary to get there. We invite qualified engineers and scientists to join us. Some of our immediate needs are listed in the column on the facing page. Please read it.

Arthur Shef, Chief, Advanced Design Section, Missiles and Space Systems, irons out a problem with Arthur E. Raymond, Senior Engineering Vice President of

DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

NASA, DOD Streamline Booster Effort

by C. Paul Means

WASHINGTON—The nation's space program was reorganized last week in an effort to streamline the space rocket booster programs and to coordinate civilian and military efforts in this vital area.

The results of a joint action taken by the Department of Defense and the National Aeronautics and Space Administration were to:

- Establish a new department in NASA to direct the space booster program;
- Appoint Air Force Major General Don R. Ostrander—presently Deputy and Acting Director of ARPA—to head the new organization as Director of Launch Vehicle Programs;
- Downgrade the status of ARPA by requiring its director to report to Pentagon R&E chief Dr. Herbert York rather than to the Secretary of Defense;
- Appoint Army Brig. Gen. Austin W. Betts—presently Dr. York's military assistant—to take Gen. Ostrander's place as Director of ARPA.

Gen. Ostrander will take his new job Jan. 1. He will remain on active duty with the Air Force.

The Ostrander agency was carved out of the organization presently headed by Dr. Abe Silverstein. Under the new set-up, Gen. Ostrander will be in charge of the booster and launching developments (including Project *Saturn* and the ABMA's Development Operations Division when transferred) and Dr. Silverstein's Space Flight Development Team will be in charge of upper stages, envelope, payloads, mission planning and inflight research and operations.

MAJ. GEN. Don R. Ostrander, who takes over the top space booster job at NASA.

Gen. Ostrander, 45, was picked for the new job because of his close association with the Air Force missile programs during the past 15 years. Before coming to ARPA he was assistant to the NATO assistant secretary general for guided missiles production in Paris, and he has also held a number of administrative posts in the Air Force's ARDC.

The Pentagon's decision to downgrade ARPA made it merely an arm of York's office of Research & Engineering. Originally established after *Sputnik I* as the nation's prime space agency, ARPA held equal status with the three military services and its Director reported directly to the Secretary of Defense.

After experiencing great difficulty in obtaining a successor for ex-ARPA director Roy Johnson, the Pentagon apparently has decided to put the agency under the direct control of Dr. York. Gen. Betts, in his new post, will continue to report to Dr. York, just as he has during the time he has served as York's military aide.

Before he became the R&E chief's assistant, Betts was deputy director of ARPA's guided missile division.

When the military services take over operational control of ARPA's military satellite project, the agency will be left with four advanced research projects costing about $150 million a year. These include a missile defense program, a solid propellant program, a materials research program, and a research project investigating ways to police a nuclear test ban.

Navy Seeks Anti-missile Birds

by James Baar

WASHINGTON—The Navy has officially disclosed that it is developing a *Super Talos* anti-missile missile.

It also made it clear that it is working on the problem of developing missiles capable of destroying Soviet IRBM's shortly after they are launched from Soviet submarines.

The disclosures came in the release of secret testimony given before the House Space Committee in June.

The Navy only a few months ago denied the published report (M/R, Sept. 21) that it was developing an anti-missile missile.

The report disclosed that the *Super Talos* was being developed for use against air- and surface-launched missiles fired at surface ships. It said the advanced **Bendix** *Talos* also might eventually be used for defense against submarine-launched missiles and possibly against ICBM's.

The House committee heard Vice Adm. J. T. Hayward, Deputy Chief of Naval Operations for Development, and Rear Adm. Rawson Bennett, Chief of the office of Naval Research, testify on the Navy's anti-missile missile program. Both admirals appeared at a closed hearing.

The heavily censored testimony did not mention *Super Talos* by name, but merely spoke of improvements in *Talos*. However, it made clear that the improved models are being designed to defend the U.S. fleet "against short and intermediate range" ballistic missiles.

The testimony stressed that work on "various means" of knocking down missiles shortly after they are launched from submarines was still in the study stage.

The need for a defense against submarine-launched missiles as quickly as possible has become increasingly evident in recent months.

Top Navy officials have confirmed unofficial but reliable reports that the Russians already have the capability of launching missiles from their fleet of large diesel-powered submarines. Moreover, the Russians are reported to have a number of nuclear-powered submarines under construction. Within the next few years, both the Atlantic and the Pacific coasts of the United States are expected to be bracketed with Soviet missile-launching submarines on station.

Missiles launched from Soviet submarines would skirt BMEWS—the ballistic missile early warning system still under construction—and strike U.S. SAC bases without warning.

Super Taloses could be deployed aboard the Navy's new fleet of missile cruisers, most of which are still being converted. They might also be deployed on converted battleships.

Low Estimate?

To the Editor:

Your Sept. 28 issue carried an article telling about the growth of the electronics industry in the Los Angeles area emphasizing "The Move into San Fernando Valley."

It is a good wrapup of the expansions and moves by the "big ones." However, it underestimates the size of the industry by stating that there are 461 plants here when there is approximately 600.

The map accompanying the article is somewhat misleading. Mount Wilson, Whittier, Bell, San Gabriel, Hollywood and Los Alamitos are not "some of the main industrial centers in the . . . area." Glendale, North Hollywood, El Monte, Lawndale, Downey, Alhambra have a better claim.

Jules Greenblatt,
2404 W. Seventh St.
Los Angeles 57, Calif.

Special Materials Issue

To the Editor:

R. C. Ramé of our technical staff submitted to you an article on Teflon hose, which appeared on page 52 of your Nov. 23 issue on materials. The original copy contained the figures 623°F and 650°F as temperatures at which Teflon begins to decompose, but the final text appeared as reading "623°F to—650°."

I am sure your readers will recognize the typographical nature of this error, but whether they will be confused by the presentation of these figures in connection with the operating characteristics of Teflon hose remains a question which you may wish to clarify.

J. M. Sayre
Manager
Advertising and Public
Relations Department
Resistoflex Corp.
Roseland, N.J.

Indeed we do wish to clarify an apparent discrepancy of 1300°F.—Ed.

To the Editor:

Our sincerest congratulations on your special missile/space materials issue of Nov. 23. Your staff did an excellent job on assembly and presentation of a vast amount of information.

H. Lane Losey
Supervisor
Marketing, Industrial Heating
Selas Corporation of America
Dresher, Pa.

o the Editor:

You are to be specially commended on the special issue of Nov. 23 on missile/pace materials. I do not think we have ad a better coverage with a summaion of the problems of the missile and ocket field in such a brief, concise and omplete form prior to this time. I also wish to add that we of the **Reinforced Plastics Department** of **Raybestos-Manhattan, Inc.,** feel that your reporting on the missile and rocket field is very current, accurate and interesting. In fact, all of our salesmen handling products for the rocket and missile field are required to subscribe to and read the weekly issues.

On the other side of the fence, we . . . were disappointed not to take part in your section on "Missile Suppliers Speak." We have, and are marketing, very successful materials in the ablation-resistant, insulation, and high strength-to-weight ratio fields. Tons of these materials are being used in current missile programs and it is very disconcerting to an asbestos concern to see little emphasis and favorable reporting given to asbestos-reinforced plastics when there are so many successful applications in the field . . .

M. M. Gibson
Product Manager
Reinforced Plastics
Department
Raybestos-Manhattan, Inc.
Manheim, Pa.

M/R plans to report on missile and space vehicle uses of asbestos in an early issue.—Ed.

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more about the missile week

• **United Nations, N.Y.**—Soviet bloc countries will be given seven of 24 seats on a permanent U.N. body to regulate peaceful uses of outer space under a tentative agreement worked out between the United States and Russia. The remainder of the group will include representatives from 12 Western nations and five neutral countries.

• **London**—Britain is being advised by the government-sponsored Advisory Council on Scientific Policy to stay out of the space race, except possibly for minor participation in cooperation with the United States or on some international project. The Council said it would be "folly" to seek national prestige through costly space programs when the money would be better spent on helping the Commonwealth's underdeveloped colonies and partner nations.

• **Washington**—Several multi-million-dollar missile contracts were announced by the Defense Department. **Douglas Aircraft** received a $4.5-million award for kits to convert *Nike-Hercules* missiles for use at semi-mobile installations . . . **Western Electric** received a $11.9-million contract for improvements on the *Nike-Hercules* system and a second $3-million contract for *Nike* repair parts . . . A $2.3-million contract for continued R&D of the Army's *Sergeant* missile was awarded the California Institute of Technology . . . **Bendix Aviation,** Baltimore, has a $15-million Army contract for work of a classified nature . . . For Project *Defender,* **Raytheon Co.** has a $14-million tracking radar contract and **Radio Corp. of America** has a $3.9-million contract for modifying BMEWS units . . . and **Avco-Everett Research Laboratory** has an Air Force contract for $4.8-million to continue ICBM re-entry vehicle studies and other classified work.

• **London**—Russia now has about 100 principal missile bases and 200,000 missilemen, according to an Institute of Strategic Studies report sponsored by the Ford Foundation. The missiles—*T-3* ICBM's and *T-2* and *T-4* IRBM's—were said to be concentrated along the Baltic coast, in East Germany, in the southern Ukraine and in the Carpathian Mountains.

• **Burbank, Calif.**—**Lockheed** is forming a new subsidiary—**Lockheed Electronics Co.**—which will be comprised of its recently acquired **Stavid Engineering Inc.** and the Lockheed Electronics and Avionics Division (LEAD). These will become the Stavid Division in Plainfield, N.J., and the Newport Division in Newport Beach, Calif. Former Stavid president David F. Sanders will head the new company.

• **Tokyo**—Despite strong opposition from residents, the Japanese Defense Agency plans to start building a $766,000 missile testing ground on Nijima Island, 100 miles south of here, by next fall.

• **Azusa, Calif.**—Development of two solid-state precision timers with three-pole double-throw contacts which eliminate the need to have relays for additional contacts is announced by **Aerojet-General Corp.** The two units are a 30-millisecond to 30-second short period timer and a 30-millisecond to 30-minute long period timer.

• **Washington**—Mergers & expansions: **Harris-Intertype Corp.,** Cleveland, is acquiring **Polytechnic Research and Development Co.** from Polytechnic Institute of Brooklyn . . . Robinson Technical Products Inc., Teterboro, N.J., and **Kensico Tube Co., Inc.,** Mt. Kisco, N.Y., have agreed on a merger . . . **Dynatran Electronics Corp.** is a newly formed company joining the semiconductor field . . . and **Convair** is building a $276,000 engineering space research lab at San Diego which will be equipped with two 12-by-20-foot vacuum tanks to simulate space environments.

Monkey Returns Safely From *Mercury* Escape Test

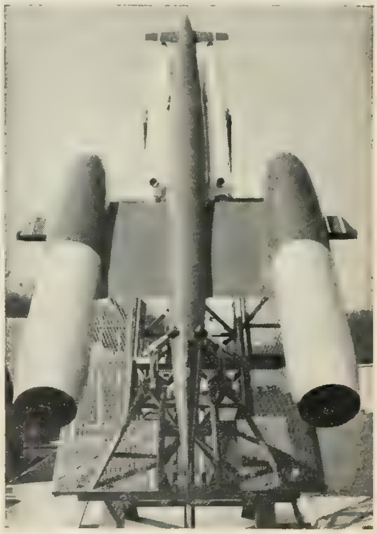
WALLOPS ISLAND, VA.—The National Aeronautics and Space Administration on Dec. 4 successfully recovered a 2½-year-old, seven-pound rhesus monkey from the ocean after it had flown to an altitude of 55 miles in a Project *Mercury* capsule.

The monkey, named Sam, apparently suffered no ill effects.

The capsule was lifted by the *Little Joe* vehicle built by the Missile Division of **North American Aviation.** It is powered by four Castor and four Recruit solid-rocket motors manufactured by the **Thiokol Chemical Corporation.**

Purpose of the flight was to test the **Grand Central Rocket Company's** pilot escape system at high altitudes, and to observe the monkey's reaction to high acceleration and weightlessness.

The capsule was picked up in the Atlantic 200 miles from Wallops Island by a destroyer.



NORD AVIATION'S CT-41 target missile will be made under license in Britain by Hawker-Siddeley. The supersonic bird has two wingtip-mounted ramjets and is controlled from the ground.

Hébert Group Releases Bahamas Guest List

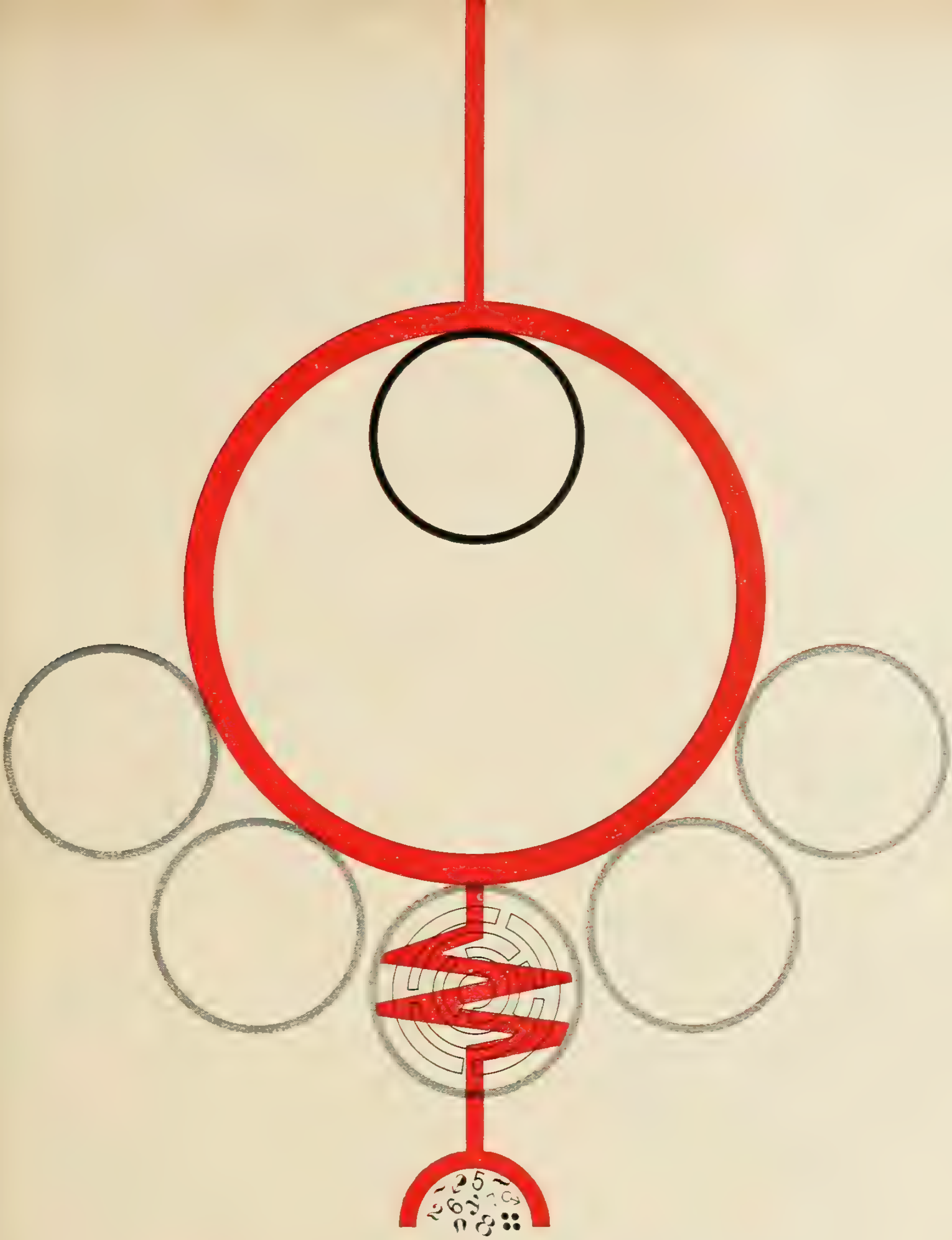
WASHINGTON—The House Armed Services Investigations Subcommittee this week made public the following list of persons entertained by **The Martin Company** at the Cotton Bay Club in Eleuthera.

Civilian governmental officials: **AF Secretary James Douglas** (who confirmed he had been a guest, but paid his own expenses) and **FAA Administrator Elwood Quesada.**

Air Force: Generals Nathan F. Twining, F. F. Everest, Emmett O'Donnell, S. E. Anderson; Lt. Gen. John K. Gerhart; Major Generals H. M. Estes, James Ferguson, J. E. Smart, E. J. Timberlake; Col. I. F. Larkey.

Navy: Vice Adm. J. T. Hayward; Rear Admirals C. D. Griffin, W. K. Mendenall, Jr., C. B. Martell, C. J. Pfingstag, W. A. Schoech, T. B. Clark, F. M. Hughes, D. L. McDonald; Captains Frederick A. Bardshar, M. V. Beebe, H. D. Helfrich, T. W. South; Col. J. K. Dill, USMC, Lt. Col. J. B. Berteling, USMC.

Other guests: Harold Stuart, former Assistant Secretary of Air Force; Lieutenant Generals Richard Sutherland, and Joe Smith, USAF retired; Maj. Gen. K. McNaughton, USAF retired; retired AF Colonels Thomas Belshe and A. R. Christie; golf professionals Gene Sarazen and Max Elbin; and Norman Hayes, NAA; Dan Kimball, **Aerojet-General**; Alex M. Knapp, insurance consultant; L. D. Lyman, **United Aircraft**; Watson Newhall, **Flight Refueling, Inc.**



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west coast industry . . .

By FRANK G. McGUIRE

There are some interesting breakdowns in the $1.8 billion in contracts now outstanding which were let through the Los Angeles Ordnance District. This office buys about $400 million yearly for the Army and ABMA. Of this, the bulk is on behalf of the Army Rocket and Guided Missile Agency, and officials expect the amount of ammunition and related ordnance items to triple in the coming year. One third of the total contracts are for R&D work, the remainder for production. Another interesting point is that one third of the total were originally let in the East, but for various reasons were transferred to the West Coast for performance.

The 1600 active contracts administered make it the largest ordnance district in the country. Covering southern California, the office also has jurisdiction over Utah, New Mexico, Arizona, and parts of Texas and Nevada. Despite this spread, 95% of the district's business is placed in the Los Angeles area, where facilities and talent abound. Parts for every Army missile system are bought here. Col. Paul H. Scordas, Chief of the LAOD, sees the trend increasing business on the Coast.

Summers Gyroscope Co.'s first profitable month . . .
since January, 1957, was October. November was also in the black. The company, a holding of the **Atlas Corp.,** feels it has reached the turning point in its financial history, and hopes to be in the black next fiscal year beginning Feb. 1. The possibility of a merger for Summers has been cropping up, but apparently no firm moves have been made as yet.

Aerojet's twist on a Madison Avenue trick . . .
was introduced in a company film on the hydrogen-fueled engine under development. During post-firing inspection of the engine, a white-gloved engineer ran his hand over the inside of a rocket engine recently fired with hydrogen, then a similar test on the chamber fired with hydrocarbon fuels. The difference in cleanliness was obvious, they say.

Sandia Corp. is considering moving . . .
its range at Salton Sea in southern California, because of the encroachment of civilization upon its facilities. The firm may shift operations northward to the area around Tonopah, Nev.

Humane Society of the U.S. . . .
has filed a complaint through its California Branch, against space research conducted with animals which results in cruelty. Emphatically disassociating itself from antivivisectionist groups, HSUS, objects to unnecessary cruelty attendant to legitimate biomedical research. Attempts are being made to persuade Congress that a rider be included in every government research grant involving animals, that proper anti-cruelty measures be established and maintained.

Leach Corp. is intensifying development . . .
of power equipment, through its **Inet Division.** The company, a leader in power generation and control equipment for ground support, has been accelerating development and reliability programs in all its divisions as part of an expansion into the electronic components and systems field. The company recently instrumented Air Force Captain Kittinger in his 76,400-foot drop from a balloon gondola.

Western Gear Corp.'s new metrology lab . . .
is in operation at the firm's Lynwood facility. The lab has ultra-precision capabilities, necessitated by the company's expanded activities in tracking antennas, radio and radar telescopes and other space guidance devices.

Navy has been plagued by security gaps . . .
resulting from a main railroad line running through its top-secret activities at Point Arguello. Passengers have an unobstructed view of things, so Navy is not-too-seriously thinking of building a solid line of billboards along the tracks, and selling space to missile contractors.

people

Donald M. McGrath has been appointed vice president and general manager of the Hufford Division of The Siegler Corp. In his newly created post, McGrath will be responsible for administration, engineering, production and sales.

Prior to joining the firm, he served nearly three years as plant manager of Solar Aircraft Co. Before that, he was associated for 21 years with Bendix Aviation Corp.

Jack J. Bromberg, who directed development of the *Thor* missile program for the Douglas Aircraft Co., has been named program manager for the company's *Nike-Zeus* activities.

Paul Swan, another pioneer missileman with Douglas, will serve as assistant *Zeus* program manager.

Dr. Nisson A. Finkelstein has been appointed assistant vice president and director of research of the Stromberg-Carlson division of General Dynamics Corp. He succeeds **Lynn C. Holmes,** who has been elected director of engineering operations.

Prior to joining the firm, Dr. Finkelstein was assistant director of the scientific bureau of Bausch & Lomb Optical Company, a position he had held for the past three years. He joined Bausch & Lomb in 1950 as a research physicist.

Gene L. Armstrong, chief applied mechanics engineer for Convair (Astronautics) Division of General Dynamics Corp., has been promoted to the post of senior project engineer for airborne systems on the *Atlas* missile program.

He was an aerodynamicist with Boeing Airplane Co., a specialist in the field of automatic control and servomechanisms with North American Aviation Co., and became a design specialist for Convair-San Diego in 1954.

Dr. William Walton Carter has recently been named chief scientist of the Army Ordnance Missile Command at Redstone Arsenal. Dr. Carter came to the AOMC post from the Los Alamos Scientific Laboratories of the Atomic Energy Commission, where he was director of the Experimental Physics Group, Weapons Division.

David J. Barnett has been appointed assistant project manager to **Abraham Lazar,** project manager, for the development work conducted at Bulova Research & Development Laboratories, Inc., on the *Pershing* ballistic missile warhead section.

Barnette had been a project engineer in the Labs' *Pershing* design group and served with the Navy as a nuclear weapons instructor.

Hercules Powder Company's Chemical Propulsion Division has announced the addition of three rocket and missile propellant specialists to the staff of the Plans and Program Group: **Austin B. Chappelle,** former Martin Co.-Orlando, chief engineer for propulsion; William D. Kelley, Jr., previously manager of quality control for Thiokol Chemical Corp.'s Utah Division, and **John A. Scherer,** formerly with Westinghouse Electric Corp.

Nicholas H. Johns has been named executive engineer for Data-Control Systems, Inc.'s research and development department. He was previously associated with Electro-Mechanical Research, Inc., in environmental test and redesign work for the *Titan* program.

C. P. Clare Transistor Corp. has announced the election of **Amos Kaminski,** former chief research scientist with General Transistor Corp., as president. The new firm is a sister company to C. P. Clare & Co., manufacturer of relays and allied electronic components.

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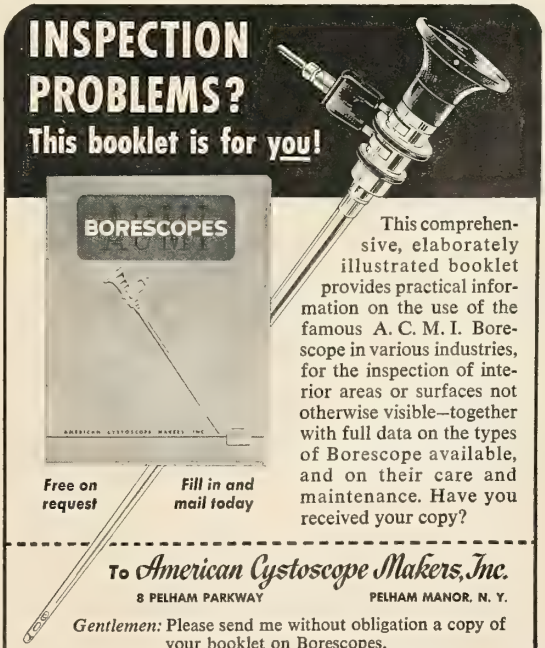

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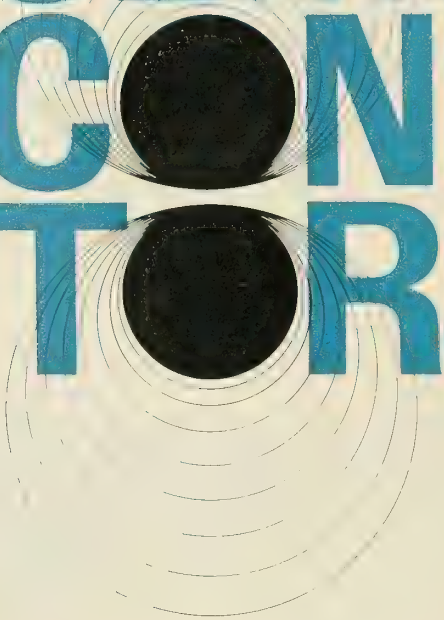

IBM's explorations in the semiconductor field include theoretical and experimental studies in basic semiconductor science as well as development of advanced devices and technologies. In one current research project, for example, a better physical understanding of the origin of the negative resistance characteristic of the Esaki diode is being sought. At the same time, development engineers are exploring applications of this device and have already produced a new solid state oscillator of exceptional simplicity in the 3,000 megacycle range. To date, this represents the deepest incursion into the microwave region via semiconductor electronics. In another project, an NPN double-diffused high-speed drift transistor has been developed that will greatly accelerate logical switching and high-power core driving. Both exploratory investigation and development of these and related electronic devices are expanding at a rapid pace at IBM. To further these programs, well-qualified specialists are required for all areas of device exploration.

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people...

Royal Industries, Inc., has announced the appointment of **Harry Houdyshell** as chief engineer and **Dean Oleson** as assembly superintendent of the company's Pacific Electronic Controls Division.

Houdyshell is former chief product engineer of the Helipot Division of Beckman Instruments, Inc., and Oleson was formerly factory supervisor of the Poco Tiempo Division of Helipot.

Paul F. Ziegler has been named technical director of Johnston & Funk Metallurgical Corp. and will supervise all research and development programs.

For the past seven years Ziegler has been associated with Fanstell Metallurgical Corp. as a metallurgical engineer.

Dr. Maurice Nelles has joined American Electronics, Inc., to fill the newly created position of Vice President-Engineering. He will direct the engineering planning for the corporation and its nine divisions.

Prior to joining the firm he was Vice President-Research and Development, and Chairman of the Corporate Product Planning Committee of Crane Co.

Houston Fearless Corp. has elected **John A. Beckman,** formerly of Hughes Aircraft Co., manager of its communications and space projects. Beckman, who has been with the Hughes communications division since 1953, has recently managed systems development and the advanced projects department, being responsible for technical direction of data transmission and processing systems.

Prior to his association with Hughes, he served seven years with the National Security Agency, supervising development of electronics security systems.

Anthony Del Duca has been appointed chief engineer at Metrolog Corp., a division of Air Logistics Corp.

Del Duca's previous positions included chief engineer for electronics at Beckman Instruments, senior engineer in charge of advance transistorized circuitry on the *Terrier* at Convair, and senior research engineer in the Radar and Fire Control Group at Autonetics.

Dr. Jacob P. Den Hartog, professor of mechanical engineering at the Massachusetts Institute of Technology, has accepted the position of guidance test manager with the Air Force Central Inertial Guidance Test facility at the AF Development Center, Holloman AFB, N.M.

J. R. Madigan has been named senior scientist at the Roy C. Ingersoll Research Center of Borg-Warner Corp. He was formerly vice president and director of engineering of the Semiconductor Division of Hoffman Electronics Corp. Prior to that he was assistant professor and director of the Solid State Physics Laboratory at the Illinois Institute of Technology and associate physicist at the Armour Research Foundation.

when and where

DECEMBER

23rd Wright Brothers Lecture: **High Temperatures in Hypersonic Flow—Physical Principles and Experimental Techniques,** Natural History Bldg., Smithsonian Institution, Washington, Dec. 17.

American Chemical Society, Industrial and Engineering Chemistry Division, 1959 Christmas Symposium: Mechanisms of Interfacial Reaction, Shriver Hall, Johns Hopkins University, Baltimore, Dec. 28-29.

JANUARY

Gas Dynamics Colloquium on Electrostatic Propulsion, University of Michigan, Ann Arbor, Jan. 7.

Sixth National Symposium on Reliability and Quality Control in Electronics, IRE, EIA, AIEE, ASQC, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

First International Space Science Symposium, and COSPAR Plenary Session, sponsored by COSPAR, Nice, France, Jan. 11-16.

Society of Plastics Engineers, 16th Annual Technical Conference, Conrad-Hilton Hotel, Chicago, Jan. 12-16.

Gas Dynamics Colloquium, Shock Tube Research, University of Michigan, Ann Arbor, Jan. 14.

American Astronautical Society, Sixth Annual Meeting, Statler-Hilton Hotel, New York City, Jan. 18-21.

Gas Dynamics Colloquium, Structure of Strong Normal Shockwaves, Northwestern University, Evanston, Ill., Jan. 21.

Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York City, Jan. 25-28.

Gas Dynamics Colloquium, Research in Rarified Gas Dynamics, Northwestern University, Evanston, Jan 28.

Seventh Annual Western Spectroscopy Conference, Asilomar, Pacific Grove, Calif., Jan. 28-29.

American Rocket Society, Solid Propellants Conference, Princeton University, Princeton, N.J., Jan. 28-29.

FEBRUARY

Chemical Institute of Canada, Toronto Section, Symposium on Gas Chromatography, Seaway Hotel, Toronto, Ont., Feb. 1.

Instrument Society of America, Houston Section, Instrument-Automation Conferences & Exhibits, Rice Hotel and Sam Houston Coliseum, Houston, Feb. 1-4.

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We Can Catch Russians in Space

The real exploration of space will begin when this country or some other establishes a rendezvous capability in the solar system. Whether this capability is a space platform, which is most likely to come first, or a base on the moon is not too important. But all of the probes and studies now being carried on lead inevitably to this one focal point—the rendezvous in space where men and material can be assembled outside the atmosphere. This will be the base camp, the assembly point, the launching platform for the conquest of space.

The U.S. space program, if judged without an invidious comparison with the Soviet accomplishments, has not been trivial. From an almost standing start in 1956, the nation has achieved many significant successes—the *Discoverer* series, the paddlewheel satellite and the recent recovery of Monkey Sam are instances. Our failures have come dismally in the big prestige events—and in the lack of a national step-by-step program aimed at a realistic and significant goal.

Where should we be going? Warranted or unwarranted, there is an almost universal feeling among scientists, industry and the military that the nation's space program is at present on dead center; that the present Administration fails to recognize its importance; that we have no real space plan; that no significant action will be taken until we have a new head of government.

In discussions with military, industrial and other civilian space authorities, we have found no real doubts that America has the national courage, skills and basic techniques to overtake and pass Russia in the space race—*if we start now.* The starting means adequate funding, enthusiastic support and a real desire to win.

The plan—or schedule—encompasses nothing we have not already started, nothing we could not accomplish. Its five basic phases are:

1. *Saturn,* the 1.5-million-pound-thrust clustered booster.
2. The Rendezvous Capability.
3. The improved hydrogen engine for upper stages.
4. The nuclear engine.
5. *Nova,* the clustering of 1.5-million-pound-thrust single engines to produce 6 to 8 million pounds thrust.

The status of those five projects at the moment is:

Saturn—the project has slipped badly from lack of funds. It will be static-tested in the summer of 1960, fired with two or three stages in 1963, and probably not launched at full strength (with all four stages) until 1964. A total of eight or ten vehicles probably will be built. The funding for Fiscal 1960-61 may reach $150 million. Few outside the Administration believe this is enough.

Rendezvous capability—This is fundamental to establishing a space platform (or moon colony) for a space laboratory, exploration collection and launch-point, or for military purposes. Projects *Mercury* and/or *Dyna-Soar* could place men at a meeting place in space. Project *Centaur,* whose first use will be for moon and Venus probes, will have the capability probably in 1962 of sending up a 900-plus-pound space platform. There are, however, no plans for a space platform and no program to train men to handle it. The development of such a platform and the training of personnel are at least two-year programs which should be under way now.

The hydrogen engine is essential to provide higher energy and performance in second stages. Such an engine could, for instance, double the payload of *Saturn.* The status of the hydrogen engine is that Pratt & Whitney will deliver the first XLR-115 this year under an Air Force contract that has had both ARPA and NASA funding. The engine will have a thrust of 15,000 to 20,000 pounds. A larger, improved engine to produce 10 times that thrust—up to 200,000 pounds—could be coming off the production line in about two and a half years—with proper funding.

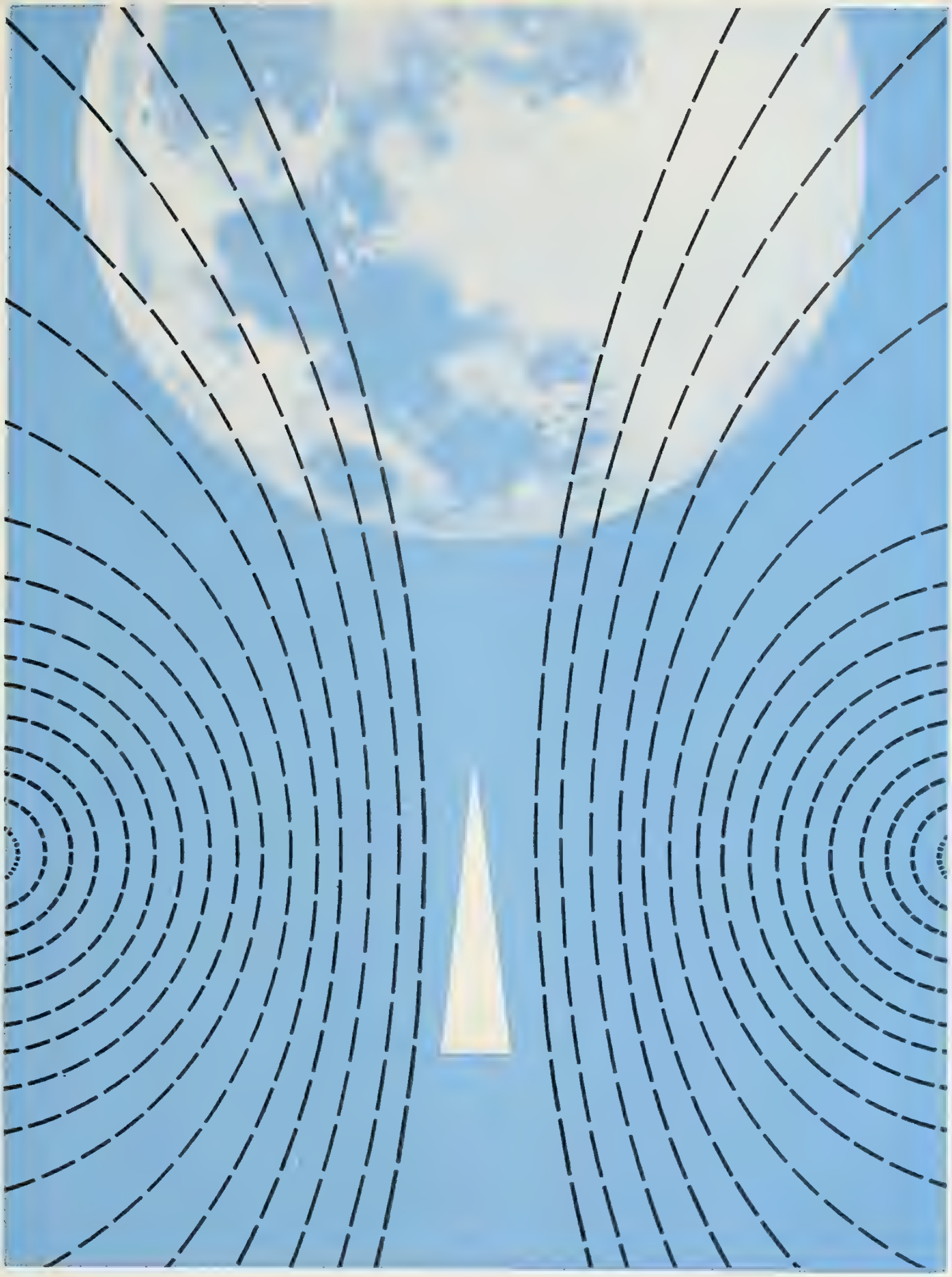
The nuclear engine is fundamental to any real space exploration, either as second stage or for final energy. It has been the undernourished stepchild of the Administration and its future depends largely on funding. A Model-T version may be ready in the 1962-63 time period. The need: money and emphasis.

Nova is the project of clustering probably four of the F-1 Rocketdyne 1.5-million-pound-thrust engines as a super booster. The F-1 could be available only a few months after the *Saturn* in 1964. It should be more reliable and much cheaper. Clustering it might take another 18 months, although this could be speeded up if a parallel program could be established during its final development.

With such a program or a variation of it, our nation would have a reasonable chance of catching up with the Russians and even eventually passing their achievements which at the moment have left the U.S. far behind.

But to do this the program must begin now. There is a minimum of 15 months' time lag from the time any space project is ordered and the time it can be accomplished. We cannot afford to wait until our space lag becomes an election issue, until a new administration recognizes the dangers inherent in losing the space race. We are losing or have lost our world technical prestige. Lagging behind so far that we may be denied access to space will mean losing our world.

CLARKE NEWLON



Avco's magnetic spaceflight—
When man first travels beyond the moon, the thrust may well be supplied by a new system of propulsion, based on principles of magnetohydrodynamics (MHD). This system uses a magnetic field to speed and expel ionized gas for power output. Magnetic thrust propulsion is a current project of the Avco-Everett Research Laboratory . . . working to extend the knowledge of man.

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"Hound dog" makes a B-52's shadow broader than the state of Texas

Those sharp-nosed missiles slung close to the fuselage beneath the wings of a SAC B-52 intercontinental bomber are GAM-77 HOUND DOGS with a range of several hundred miles apiece. Thus equipped, the B-52 can reach out to blast enemy resistance points over a huge area along the route to its central target.

In actual combat the inertial guidance systems in the missiles would be fed their target locations, then the missiles would be released to find their way to target at supersonic speed. Locked on target from the time of leaving the "mother ship," the missiles could be neither jammed nor decoyed.

Hound Dogs are now rolling off the production lines into flight test. Alternate missiles are being assigned to a crew, half of which consists of USAF men. This is part of the Air Force's "Blue Suit Integration Program."

The Missile Division of North American Aviation is the weapon system contractor for the GAM-77.

MISSILE DIVISION
NORTH AMERICAN AVIATION, INC.
Downey, California

DECEMBER 21, 1959

TLAS ON THE PACIFIC—
ANDENBERG VS ARGUELLO

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

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ga Dropped in Favor of *Centaur* 1

mputer Simulation of Lab Tests 19

AN AMERICAN AVIATION PUBLICATION

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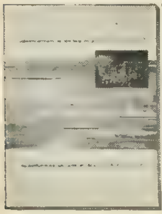

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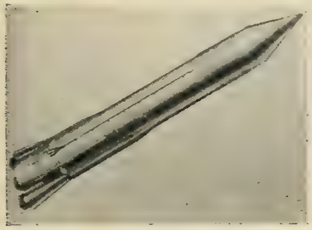
missiles and rockets

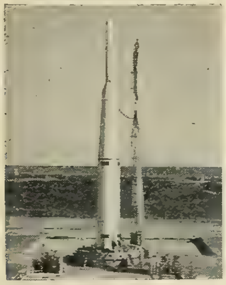
MAGAZINE OF WORLD ASTRONAUTICS

31,000 copies of this issue printed

COVER: *Atlas* on a launching pad at Vandenberg AFB, Calif., symbolizes the intensified struggle between the Air Force and the Navy over who'll be top dog in West Coast missile and space launching. See p. 10.



OUT OF space picture now is the projected *Vega* vehicle. The *Centaur* will be used for most of the U.S. space jobs of the future; *Agena* will be used in the interim. See p. 15.



THREE-STAGE *Thor-Able* was to have been used in attempt to put a 95-lb. probe in orbit around the sun. For a background story on the planned shot, turn to p. 17.

SCALE MODEL of *Mercury* space capsule, with escape tower attached, is tested in the Propulsion Wind Tunnel, Air Force's Arnold Engineering Development Center. See p. 24.

DECEMBER 21 HEADLINES

AF, Navy Fight for Top West Coast Launching Role
The Air Force wants to use *Atlas* pads at Vandenberg for polar-orbit launchings which would cross Navy's Pacific Missile Range facility at Point Arguello; Navy is already bothered by Vandenberg's effect on PMR. A special report 10

Background on the Postponed *Thor-Able* Probe 17

The Air Force Reappraises the *Titan* Program
The Ballistic Missile Division reportedly has concluded the missile is basically sound and has place in defense plans; upshot may be thorough congressional investigation of entire ICBM picture ... 43

ASTRONAUTICS ENGINEERING
U.S. Reg. Pdg.

Vega* Out, Hopes Pinned on *Centaur
Delay in schedule thought to be primary reason for cancellation and reshuffling; the Air Force's *Atlas-Agena* will be used as an interim vehicle 15

Picture Story of Testing at ARDC's Tullahoma Wind Tunnel Facility 24

Curtiss Develops an Expendable Drone 28

ASTRIONICS

Computer Simulation of Lab Tests May Save Time, Money
Experiments during design phase indicate considerable economies are possible along with improved reliability; C-E-I-R's approach is described 19

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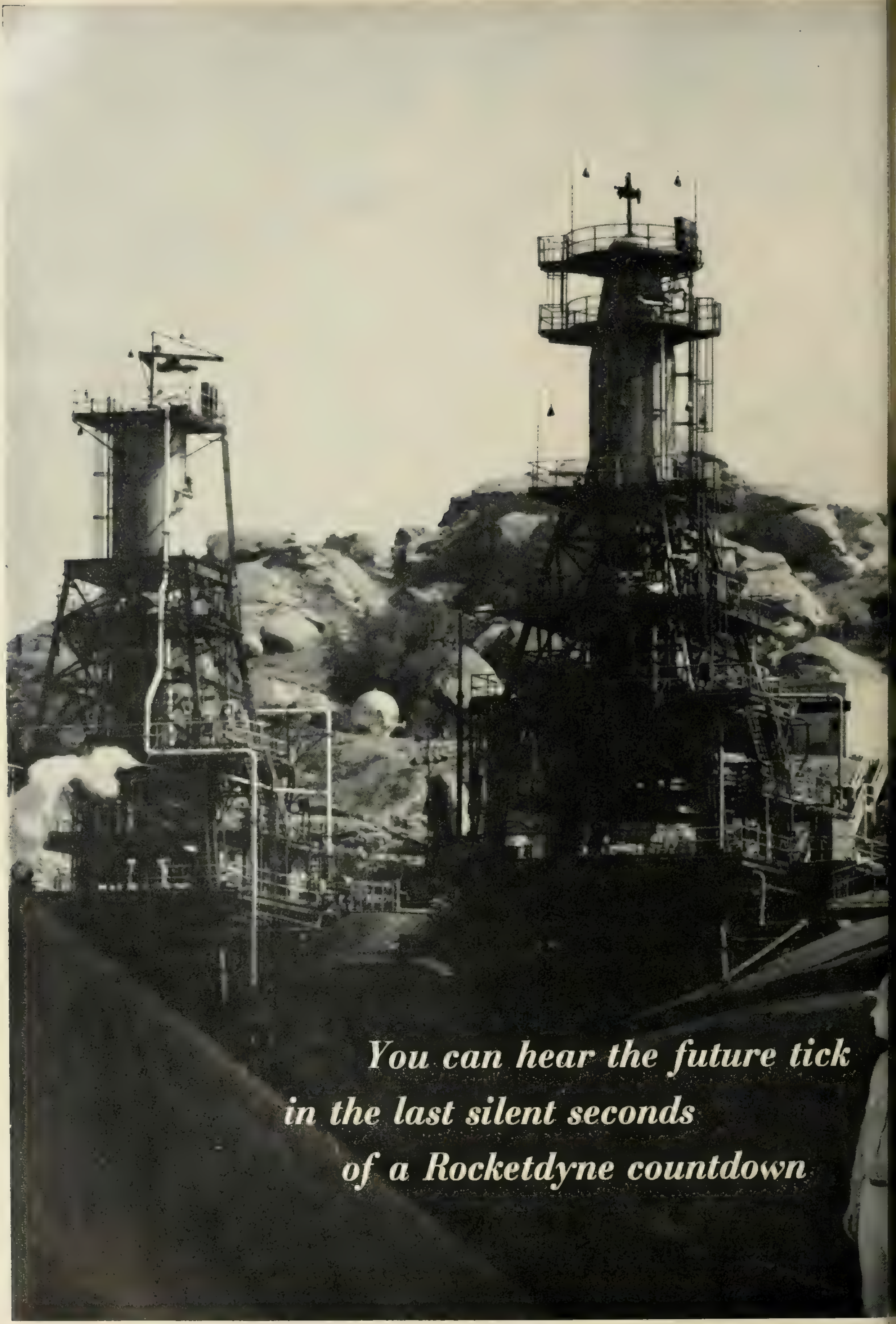

You can hear the future tick
in the last silent seconds
of a Rocketdyne countdown

FOUR...THREE...TWO...ONE... a moment of silence. Then a giant speaks—and a bolt of man-made lightning flashes.

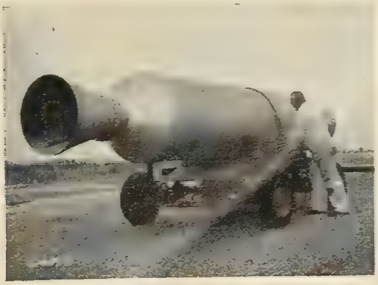
Nearly every hour of every day, Rocketdyne technicians near that dramatic moment as they test and tune the space engines of today.

The best-equipped test facilities for high thrust rocket engines in the nation are at their command. Rocketdyne's finely instrumented test structures are located in California's Santa Susana Mountains; Neosho, Missouri, and McGregor, Texas.

Rocketdyne engines have powered most of the military and scientific projects conducted by the Air Force, Army, and NASA. Now huge boosters of one and a half million pounds of thrust are emerging from the technical heritage of Atlas, Thor, Jupiter, and Redstone.

And even while today's countdowns go on, plans for tomorrow's assault on space are being made. At Rocketdyne, engineers and scientists are investigating such advanced forms of propulsion as ion engines, nuclear engines, plasma jets, and magnetohydrodynamic engines. Meanwhile other groups are at work on high-energy liquid and solid propellants, and dramatic new devices for both liquid and solid propulsion systems.

Rocketdyne, a 12-year pioneer in rocket technology, was first with power for America's long-range ballistic missiles—first with power for Outer Space.



MEGABOOM—a giant solid propellant rocket motor produced at Rocketdyne's McGregor, Texas, solid fuel facility—delivers 100,000 pounds of thrust, boosts test sled to 1,200 mph.

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Washington Countdown

IN THE PENTAGON

The Crow . . .

is a new Navy missile currently under development. The missile—reported to be air-to-air—has already undergone flight tests.

• • •

The *Titan* . . .

ended its latest flight test in flames and a mushroom cloud because a short-circuit accidentally tripped the big bird's destruct mechanism during the launching from Cape Canaveral. The C-model of the **Martin** ICBM included a live second stage which would have been fired for the first time.

• • •

Decision on the *Thor-Delta* . . .

controversy over where to build a pad for launching the new NASA-STL vehicles into polar trajectories is expected within the next two weeks. The question to be decided at the Pentagon: Should a new pad be constructed at the PMR's Point Arguello or should a Thor pad at neighboring Vandenberg AFB be modified? The first *Thor-Deltas* are scheduled to be available next year. (See page 17.)

• • •

More range, more accuracy . . .

is built into **Douglas'** new Super *Honest John*. The improved Army tactical missile also is shorter and more easily transported than its 16-mile range predecessor.

• • •

Less pounds, less dollars . . .

is the reason given by the Marines for choosing **Daystrom's** *Cobra* anti-tank missile for evaluation over the Army's **Nord** *SS-10* and *SS-11*. The Marines have bought 100 of the *Cobras*—a product of Daystrom's West German subsidiary, **Boelkaw.** Cost per copy: About $1000. (See page 16.)

• • •

Production stretchouts . . .

for the **Convair** *Terrier* and *Tartar* programs are expected during 1960. The two surface-to-air missiles with the **Bendix** *Talos* make up most of the main armament of the Navy's fleet of missile cruisers.

• • •

Development cycle cuts . . .

are the aim of a new Army regulation that would bring the "user" into the R&D programs from the beginning and calls for earlier production planning. The regulation—numbered 705-7—was issued earlier this month.

ON CAPITOL HILL

The main lines of attack . . .

of the sweeping hearings planned by the House Space Committee for next month are being worked out behind closed doors. The all-star cast of officials will begin appearing before the committee as soon as Congress opens up for business. The committee's goal: To pinpoint why we are lagging behind Russia in space and what can be done about it.

• • •

No firm schedule . . .

has been reached so far for equally sweeping hearings planned by the Senate. However, the Senate schedule is expected to be decided on by Christmas.

AT NASA

Thor-Able 4 space probe . . .

scheduled Dec. 16 was postponed by NASA apparently because of transmitter difficulty in payload. M/R on page 17 today lists the planned objectives and instrumentation of the experiment. In light of action by AFMTC Commander Maj. Gen. Donald Yates in banning the press from all military firings at Cape Canaveral (later rescinded) because a news wire service carried a story Dec. 12 of the planned firing (which, incidentally, was common knowledge in Washington for several weeks), M/R emphasizes that material for this week's article was gathered from private sources, knowledge of past programs, and in no way has this magazine violated any government news release restrictions either from the Department of Defense or the NASA.

ALONG EMBASSY ROW

France's *Matra 511* . . .

air-to-air missile is now in production for the arming of the latest French fighters. The two-stage solid missile has a range of more than four miles. *Matras* have either operated on IR or electromagnetic guidance.

• • •

West German marks . . .

are being poured out for Martin *Maces*. The German Defense Committee has approved spending $120 million for an undisclosed number of *Maces*—probably two squadrons.

Industry Countdown

MANUFACTURING

Elimination of drogue chute . . .
is being advocated by some Project *Mercury* personnel as a weight saver. They recommend using roll jets on the capsule for stabilization during re-entry and main chute deployment at 10,000 ft. However, **Radioplane** wants to retain the drogue.

• • •

New Japanese anti-tank . . .
missile TATM-2 made by **Kawasaki Aircraft** is reported to be 4.6 ft. long and weighs 300 pounds.

• • •

Over-the-counter price . . .
of air-to-air *Sidewinders* being produced by **Perkin-Elmer Bodenseewerk** near Lake Constance, Germany, is being quoted to NATO members as between $3000 and $4000 per missile, depending on the number ordered. Chief subcontractors (all under the same U.S. licensing arrangement) are **Philips-USFA N.V.**, Netherlands; **Terma, A/S Wetra, Y Hoyer Establishment,** and **Dansk Industries** of Denmark; **State Mechanical and Chemical Industries** of Turkey; **Greek Powder and Cartridge Co.,** Greece; **Kongsberg Vapenfabrikk** and **Raufoss Ammunisjonsfabrikker** of Norway.

• • •

900 lb. tungsten ingots . . .
formed from tungsten powder in high-capacity presses in sizes suitable for missile use are being produced at the **Metalwerk Plansee** in Austria. The company says they will be exported to the U.S. shortly by the **Schwarzkopf Development Corp.,** New York City.

• • •

In union contract . . .
negotiations starting in March, U.S. missile makers are expected to gear their approach pretty closely to the outcome of the steel dispute. Contracts cover 250,000 employes.

• • •

Those close to *Minuteman* . . .
program are denying reports that serious acoustic and heating problems have cropped up in silo test launchings (M/R Nov. 30, p. 11). They say all external environmental conditions have fallen within predicted range values and "no excessive deleterious effects" have been observed. The first three shots were so successful, in fact, they are making a "large reduction" in total number of previously planned silo test shots.

PROPULSION

Solid-liquid combination . . .
propels France's *Onera* four stage high altitude rocket. The 39 ft. 15-ton research vehicle has two liquid and two solid stages and has reached altitudes of 250 miles.

• • •

Leader in case competition . . .
for the first stage engine of the **Boeing** *Minuteman* appears to be **General Motors' Allison Division.** It was an Allison case that **Thiokol** tested successfully a few weeks back. **Ladish Co.** supplied the D6 steel forging and **E. W. Bliss Co.** also worked on the case.

• • •

Some private researchers . . .
are now estimating the FY 1960 demand for solid rocket fuels will be in the neighborhood of 39 million pounds. The figure is based on current budgeting for missiles. They expect the demand to rise slightly in FY '61.

ASTRIONICS

To handle the satellite . . .
command post type control center at Sunnyvale, Calif., **Radiation Inc.'s** western division is undergoing a huge expansion. Personnel is expected to reach 2500 within two years and with facilities to match. This will be larger than the parent company at Melbourne, Fla.

• • •

New space cabin simulator . . .
under development by **North American Aviation's Missile Division** in Downey, Calif., is reported capable of simulating weightlessness for days, and complete sensory deprivation for crew training. Demonstrations have been held for NASA, ARPA and ARDC.

• • •

Electronic IR scanner . . .
developed by **Philco Corp.** uses a scanning tube with a semiconductor-type window. Tests indicate the new system's sensitivity and information rate are limited only by the detector used.

WE HEAR THAT—

Nuclear division . . .
of **The Martin Co.** may expand to acquire capability in nuclear rocket engine design and manufacture. The reason: vehicle structure is inseparable from propulsion system in the management of a nuclear rocket program . . . The last class of RAF *Thor* crewmen has just wound up guidance training at the **AC Spark Plug Division of GM** . . . There's a chance the General Accounting Office may recommend a non-profit management set-up for ballistic missile programs if the Air Force shuns the job . . . NASA will replace its Cuban satellite tracking installation (closed by the political situation) with one costing $110,000 at Fort Myers, Fla.

More About the Missile Week on Page 46

Vandenberg or Arguello?

AF-Navy Space Range Fight Near

Air Force tosses Atlas pads into struggle for top space role on vast Pacific Missile Range

FIRST LAUNCHINGS—and so far the biggest—from Arguello have been *Terriers*. Soon Marines will be firing *Hawks* here.

by James Baar and William E. Howard

VANDENBERG AFB, CALIF.—Three giant Air Force *Atlas* gantries looming against the California sky are casting dark shadows across the Navy's Pacific Missile Range.

They have become the key pawns in the running Air Force-Navy struggle for the top role in the nation's R&D missile and space programs on the West Coast.

The gantries which house the nation's first operational *Atlases* stand on a plateau at Vandenberg less than 10 miles due north of PMR's key facility on Point Arguello. The two bases—Vandenberg and Arguello—lie shoulder to shoulder on the mountainous coast some 150 miles north of Los Angeles and 90 miles north of PMR headquarters at Point Mugu. Only the little Santa Ynez River separates the rival installations.

The Air Force just within the past week submitted to the Defense Department a formal proposal to convert the three operational *Atlas* pads into R&D facilities for launching military satellites into polar orbits across Point Arguello. The three pads will become available for R&D work when the Air Force completes construction of a more advanced operational *Atlas* complex here early next year.

For months there have been reports that controversy and lack of decisions on the Pacific Missile Range may have been handicapping the U.S. space effort. To get the facts of that story and others in the missile field, M/R Associate Editors Baar and Howard traveled more than 10,000 miles visiting Air Force and Navy installations to compile four special reports, of which this is the first.

Approval of the proposal could mean:

- A sharp curtailment in the build up of launching facilities at Point Arguello.
- Indefinite continuation of work-stopping missile launchings over Arguello.
- Jeopardizing future funding for large-scale expansion of the range. The Navy previously has advanced plans to spend $4 billion on PMR in the next 15 years.

The core of the interservice fight is not PMR and Vandenberg themselves, but the much bigger military issue of how to divide roles and missions in space. The Defense Department has given the Air Force the primary space mission including control of all military space boosters. However, the Defense Department has given the Navy the mission of operating PMR—potentially the world's greatest space

howdown

range—as well as assigning the Navy the *Transit* navigational satellite.

Thus the Navy considers itself still very much in the space picture. In addition to polar orbits from Arguello, PMR is designed for the launching of satellites into equatorial orbits from an as-yet-undesignated island in the far Pacific. PMR also consists of an Inland Range (extending eastward from Point Mugu to Tonopah, Nev., and Dugway, Utah) and a Sea Test Range 500 miles along the California coast nd 250 miles out to sea for naval nissiles. It currently is developing an nti-missile missile range for the Army's *Nike-Zeus* at Kwajalein Atoll nd Johnson Island.

From its inception PMR has provided instrumentation backup and safety clearance of the Ballistic Range or Air Force *Atlas* and *Thor* shots rom Vandenberg which impact from Hawaii to Wake Island. It is planning o extend this range into the Indian Ocean for *Titan* tests.

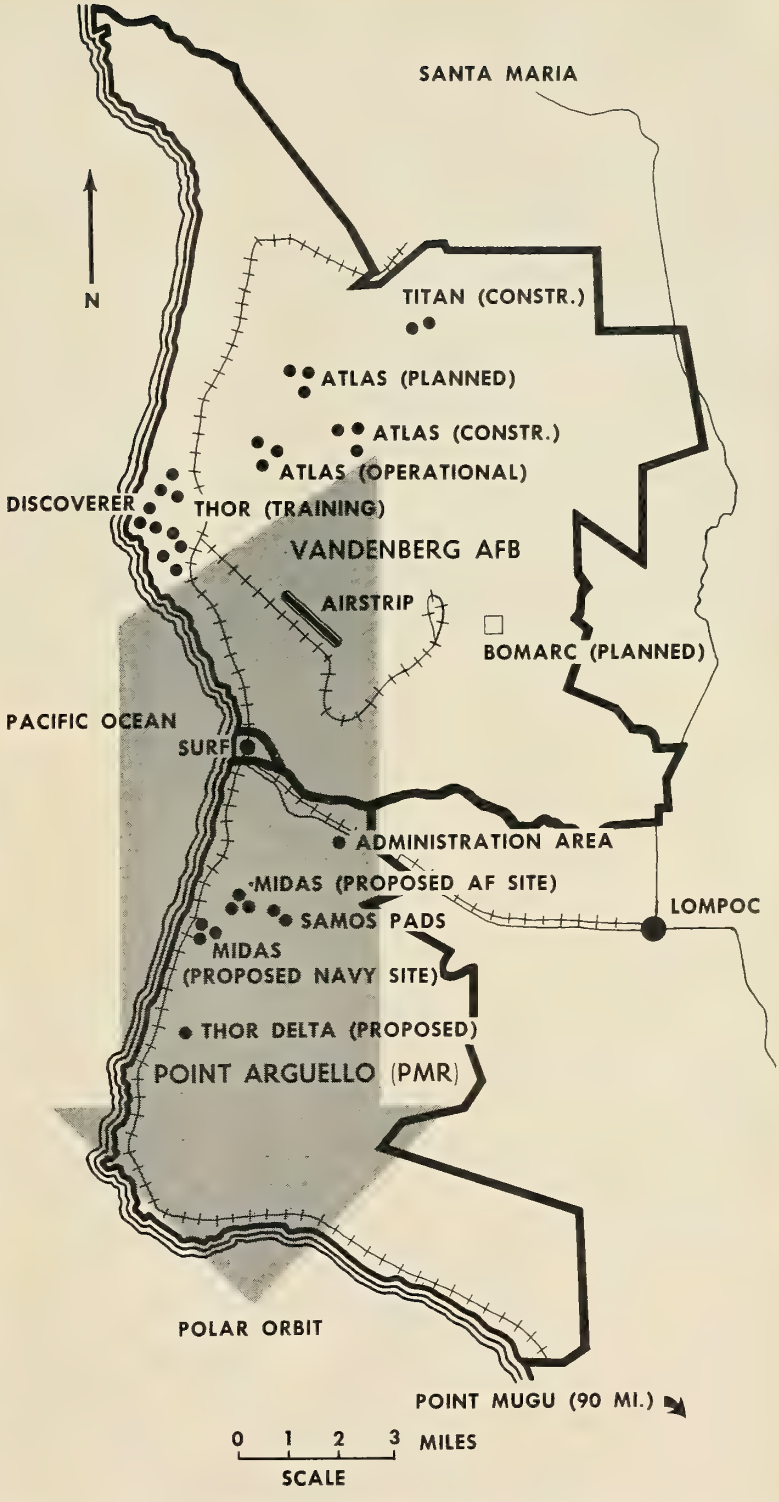
Air Force officials acknowledge the sefulness of PMR in pinpointing vhere warheads land through the Navy's underwater hydrophones. But hey contend the Air Force needs little lse provided by PMR.

Vandenberg and Arguello, at least n recent months, have lived together n relative harmony. However, behind he scenes in Washington, the fight has aged at the highest levels.

Here is the pungent way that officials on both sides are putting their ases:

Navy—"The Air Force is trying to onvert an operational and training ite into an R&D base overlapping PMR."

Air Force—"The Navy appears to e trying to parlay some ground sup-



SIDE BY SIDE, Vandenberg AFB and the Navy's Point Arguello jockey for R&D launching pads. All satellites fired into a polar orbit from Vandenberg pass over Arguello, resulting in evacuation and costly work stoppages. The Navy says evacuation is essential; the Air Force disagrees.

RUGGED TERRAIN of Point Arguello stretches southeastward along the Pacific from Mt. Tranquilon, site of PMR radars.

port equipment into an operational capability in space."

Navy—"We're a service organization with a mission to operate a national range for all comers. We're trying to build a capability to provide range services and facilities for everyone."

Air Force—"They are trying to set up a drive-in launching facility. They would like you to drive up with your bird to the gate at Arguello and hand it over to them. They take it, launch it, track it and then come out and give you the answer."

Navy—"We want to make PMR just like Cape Canaveral."

Air Force—"Our polar launching programs aren't like the R&D projects that we have at the Cape. We're trying to develop operational military systems, and when you develop these the user has to control everything that goes into the system."

• **Genesis**—The beginnings of the conflict can be traced back several years to decisions resulting from the nation's need for a launching facility from which satellites could be safely placed in polar orbits.

The area occupied by Cooke AFB (later renamed Vandenberg) was ideal. Cooke—an old abandoned Army training base in an advanced state of decay—had only recently been taken over by the Air Force as an operational missile base. Satellites could be launched southward into polar orbits from almost anywhere in Cooke without passing over any land areas before Antarctica.

William Holaday, the Pentagon's de-throned missile "czar," carved Point Arguello from Cooke and handed it to the Navy with an authorization to expand its west coast missile range facilities. The authorization was issued Dec. 7, 1957, and the PMR was commissioned seven months later on June 16, 1958.

The Marines celebrated the commissioning by conducting Arguello's first missile launching—a Convair *Terrier*. However, the range was then mainly inhabited by deer and mountain lions. Eighteen months later tracking and other range instrumentation is nearing completion and 50 miles of road have been built through the 20,000-acre wilderness. But almost all of the proposed launching facilities are still made more of paper than concrete and steel. Wildlife still abounds in the deep canyons.

While work proceeded at Arguello, the Air Force on its neighboring 60,000 acres was pushing ahead with construction of *Thor* and *Atlas* pads for operational use and training.

• **Who'll do what**—Even before PMR was commissioned, it became apparent that the two operations were inter-related and it was necessary to spell out who would do what. Accordingly, an agreement was worked ou and signed on March 5, 1958, by Ai Force Chief of Staff Thomas D. Whit and Navy Chief of Operations Arleig Burke for the "coordinated" operatio of PMR. The Navy was given responsibility for:

- Establishment of a joint radi frequency coordination agency and executive responsibility for area frequency coordination and surveillance (Frequency procurement and contro was the responsibility of individua services using the range.)
- Coordinating and scheduling o firings conducted in PMR.
- Range safety—"including actuation of inflight destruction device when required for safety for missile launched in to the PMR except fo those launched from Cooke AFB."
- Coordination to prevent undesirable duplication of facilities and equipment "in or for operation" on th PMR.
- Providing all the basic operatin facilities such as instrumentation, communications, supplies and services tha could be utilized by all range users Users with specialized requirement would have to pay for them out o their own pockets.

The agreement also stated tha "control of missile flight operation will be a function of the service sponsoring the flight." Control was define as including flight preparation of missiles and launching devices, "launching and controlling the flight through impact of the missile," and operation of the range safety equipment.

The latter provision built a contradiction into the agreement, giving the user the same control over the destruct button that an earlier provision gave the Navy.

The real operational problems began to mount with the start of the ARPA-Air Force *Discoverer* program last February. ARPA directed the Air Force to launch *Discoverer* satellites into polar orbits from Vandenberg because the necessary *Thor* pads were available there. So far none have been built at Arguello.

However, by that time—at ARPA's direction—the Navy was building two pads at Arguello for the Air Force-assigned *Samos* reconnaissance satellite. These are both *Atlas*-type pads.

Each *Discoverer* trajectory has gone over Arguello. The Navy, being in charge of range safety, has insisted upon evacuating the Point—thus halting work on the *Samos* pads. The Air Force contends evacuation is unnecessary.

The Air Force says the odds against anyone being killed by a destructed vehicle are about 200,000-to-one. However, there is even a dispute over the odds. The Navy says they are 20,000-to-one or less.

According to one story making the rounds, a high Vandenberg official ribbing a Navy officer said that even in the very remote possibility that someone were killed, this would bring honor to Arguello. The man would be the first ever killed by a ballistic missile and a big monument could be erected. The official is supposed to have added if the Navy couldn't afford the headstone, he'd pay for it.

However, the Navy sees no joke, says Rear Adm. Jack P. Monroe, PMR Commander.

"This is my personal responsibility. Safety is something you can't take lightly. It's easy to say you don't have to evacuate. But it's no accident that in firing these missiles, we've never killed anyone."

Evacuation of Arguello means that all construction workmen, administrative and range personnel not connected with the shot are cleared from the Point a half hour before launch. This can mean a loss of from several hours to several days for each shot, depending on countdown delays.

During polar launches, the Navy also halts all traffic on the main line of the Union Pacific RR which passes through both Arguello and Vandenberg, and it evacuates the little railroad village of Surf and a nearby public recreation park. The population of Surf is about 50.

The evacuations have resulted in delays of all work in the area, sizeable financial losses and strained relations among area residents.

The Navy has estimated that the cost of evacuation varies from $25,000 to $50,000 a day and that the total cost to date has been about $600,000. Slippage in the construction of the *Samos* pads has had to be built into the program.

- **Minor projects**—Point Arguello—and PMR—are now at the turning point.

The more than $200 million that have been poured into PMR in the last 18 months provide only part of the base needed for the great range that was originally planned.

Arguello today has only one major launching complex—the still uncompleted *Atlas* pads for *Samos*. All other launching facilities are minor operations in any range officer's book.

One is for NASA's *Sunflare*. This is a *Nike-Asp* sounding rocket used to collect data on the occasional great flares of burning gas shot into space by the sun.

Another is for the Atomic Energy Commission's *Tumbleweed*. This is a *Nike-Viper* sounding rocket which will be used to collect data on radiation.

Finally the Marines have been using Arguello for training troops in the firing of *Terriers* from land-based launchers. They also plan to use Arguello for training troops to launch **Raytheon's** surface-to-air *Hawks*.

The two *Samos* pads are expected to be completed early next year. Their tall gantries already tower alone over the rugged terrain. However, work on none of the other major launching

POLAR LAUNCHING of ***Discoverer*** **satellite over Point Arguello is readied at Vandenberg AFB. Operational** ***Atlas*** **gantries are barely visible at the right.**

AF rejects drive-in launch . . .

pads originally planned has been started.

At first, ARPA planned to order construction of six more *Atlas* pads at Arguello for development of *Midas*, the early warning satellite.

NASA also had plans to order construction of a pad for launching its new *Thor-Delta* vehicles. Studies were under way for construction of a huge pad for launching 1.5-million-pound-thrust rockets into polar orbits. And more studies were begun to determine what pads should be built to accomodate the launching of other space vehicles in the years ahead.

• **Picture changes**—None of this may ever become more than pieces of paper. Events have intervened.

First came the budget cutters of the Administration. As they have squeezed the budget noose tighter and tighter, the Navy has found it more and more difficult to sell the Administration any kind of overall range development program that would take into consideration the future needs of space exploration and advanced military space weapons.

The only kind of program that has had any chance of approval has been one backed up with pressing immediate requirements for projects already underway. And even funds requested for facilities of this kind have been hard to get.

The prime example is the *Midas* program. First the Administration cut the number of pads planned from six to three. Then, while the Air Force and Navy were still arguing over where the three pads should be placed, the Administration settled the matter by cancelling them, too. It said the two *Samos* pads would be sufficient for both *Samos* and *Midas*.

The range received its second major blow even as the *Midas* pads were being stripped away: ARPA, its principal military customer, was put out of the space business and the Air Force took over most of ARPA's space programs including *Midas*, *Samos* and *Discoverer*.

This meant that henceforth these programs would have to be financed with Air Force rather than ARPA funds. No one had to remind the Navy that history shows few examples of one service using its dollars to build up another service's facility.

The Air Force already had made very clear that it felt that Vandenberg should be maintained as an R&D base. Earlier this year, it had not only conducted the *Discoverer* program out over the PMR, it performed most range functions as well. And, as Arguello reached the point where it was ready to take over these functions, there was considerable reluctance on the Air Force's part to relinquish them.

• **New pact**—A new Air Force-Navy agreement supplementing the White-Burke agreement resulted. This one—signed this fall by Burke and Air Force Vice Chief of Staff Curtis LeMay—turned over to the Navy the key range function of safety and other duties. However, the Air Force retained tight control of the military systems that it was developing.

As for *Discoverer*, the Air Force said it had no intention of moving it to Arguello to stop the overflights. And there have been hints that the *Discoverer* program may be continued indefinitely.

The latest round has followed swiftly on the last. The Air Force opened it with a series of economy offers.

One—placed before NASA—proposes that one of Vandenberg's many *Thor* pads be converted for the launching of *Thor-Deltas*. The other—placed before the Defense Department—proposes that the three operational *Atlas* pads at Vandenberg be converted to R&D use.

The Air Force contends that it needs the extra R&D *Atlas* pads for *Midas*. And it says millions of dollars can be saved by converting the already-constructed facilities.

The Navy contends that use of the Vandenberg pads would make permanent the launchings over Arguello and the resulting costly evacuations. Therefore, it says, the proposals would cost more than they would save.

So far, no decision on either the *Thor* or *Atlas* pads has been reached. But money-strapped administrators are eyeing the proposals hungrily.

A factor that may influence the situation is the forthcoming report of missile range management by utility executive W. L. Cisler. He has been studying the nation's ranges for several months and is scheduled to submit his report to the Secretary of Defense about Jan. 1. He may make recommendations that would resolve the time-consuming conflict.

Meantime, the Navy and Air Force are continuing the behind-the-scenes struggle.

The stakes are clear.

If the Air Force's latest proposals are accepted, Vandenberg as an R&D center would dwarf Arguello. The PMR would in effect become a subsidiary of the Air Force.

REMOTE RADAR building under construction at Point Arguello. Wild deer are frequently spotted watching as workmen unload electronic equipment.

Vega Out, Hopes Pinned on *Centaur*

Delay in schedule thought to be primary reason for cancellation and reshuffling; the Air Force's Atlas-Agena will be used as interim vehicle

by C. Paul Means

WASHINGTON—The National Aeronautics and Space Administration cancelled the $65-million *Vega* space vehicle program last week and pinned its hopes for major U.S. space achievements (still two years away) on Project *Centaur.*

Apparent reasons for the shuffle were:

- The *Vega* schedule had slipped badly, and the early two-stage version of the vehicle was not expected to have been ready until the spring of 1961;
- Project *Centaur's* schedule had accelerated, and the successor to *Vega* now is expected to be ready by the summer of 1961;
- The Air Force expects to have its *Agena* adapted for use atop *Atlases* by the end of 1960; NASA can employ it for some missions while it waits for *Centaur.*

- **Money lost**—*Vega's* cancellation means that $17 million goes down the drain. This is the money spent on **General Electric's** engine, guidance systems for each stage, **Jet Propulsion Laboratory's** research, and **Convair's** preparations to adapt the *Vega* to the *Atlas.*

The rest of the $65 million, including funds for the six *Atlases* slated for *Vega,* will be spent on *Centaur* and to buy *Agena* vehicles from the Air Force.

Though the space agency buys very little time and actually loses some payload capability by switching to *Agena* as the interim vehicle, NASA administrators think that they may have bought some reliability. The *Agena* has operated very successfully on top of the *Thor* in the Air Force's *Discoverer* series, and they think it is possible this history of reliability will hold true for the souped-up version to be used with *Atlas.*

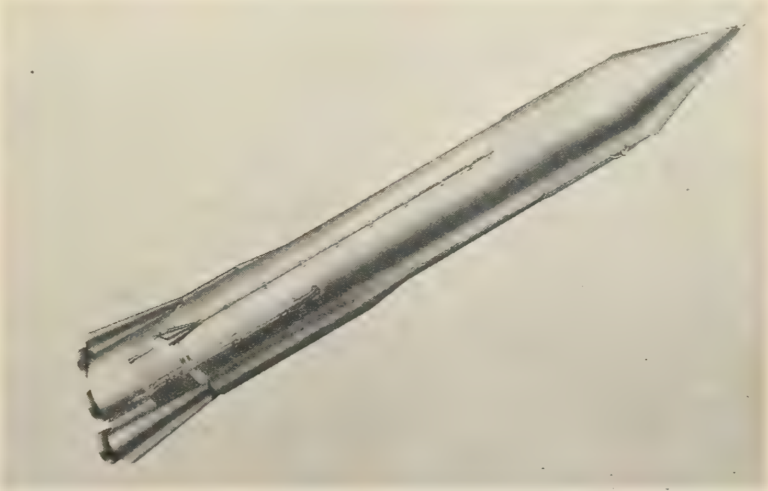
- **Time saved?**—If the *Agena* can be delivered as scheduled in late-1960, NASA may shave a few months off the two-year time period during which a lack of large vehicles—and *Atlas* boosters—threaten to bring the U.S. space effort to a standstill. (See M/R, Dec. 7, p. 30.)

The late 1960 delivery date should mean that NASA could start using the vehicle for significant missions in 1961. But it will still be late 1961 or early 1962—when *Centaur* is finally poised on its launching pad and ready to perform a full fledged space mission—that the U.S. will be able to surpass today's Soviet space accomplishments and begin to chase after the lead that the Soviets will have developed in the interim.

- *Vega's* **potential**—*Vega,* under the direction of JPL and Convair, was to have been a modified *Atlas* with a General Electric *Vanguard* engine with start and restart capability as its second stage, and a 6000-lb.-thrust, storable solid JPL 6K engine as its third stage. It was scheduled to put 5800-lb. meteorological space stations into 300-mile orbits, 740-lb. communications satellites in 22,400-mile orbits, and payloads of 1000 lbs. or more on the moon and nearby planets.

The ill-fated vehicle was to have been a forerunner and companion vehicle to *Centaur,* which has a high-energy liquid hydrogen-oxygen second stage being developed by **Pratt & Whitney.**

Centaur almost doubles *Vega's* payload capabilities and can perform more difficult missions—such as orbiting 275 pounds around the moon and then returning the payload to earth.



ARTIST'S DRAWING of ill-fated *Vega,* which had been expected to play a major role in the U.S. space effort, but has now been dropped in favor of the *Centaur.*

Centaur was catching up . . .

The main cause for *Vega's* demise is thought to be delays in its development. The two-stage version of the vehicle was expected to be ready before the end of 1960. At the time of cancellation, this schedule had slipped until sometime in the spring of 1961.

In the meantime, *Centaur* was catching up. Tests with the Pratt & Whitney two-gimballed, 15,000-lb.-thrust engines have progressed rapidly in solving the problems of high-altitude start and restart. The first *Centaur* vehicle is now expected to be ready for flight by the summer of 1961—only a few months after the target date for the two-stage *Vega*.

With space funds and *Atlas* vehicles in short supply, NASA decided to eliminate *Vega*. The nation's underfunded space effort cannot accomplish the *Lunik III* type of space mission for two years anyway, and by then *Centaur* will be able to do everything *Vega* could do—and more.

• **Alternatives**—But what of the interim period, especially 1961 when NASA had hoped it would be able to use the two-stage version of *Vega?* To keep large payloads moving into space, NASA had two alternatives:

• It could take one or more of the six *Atlases* slated for *Vega* and use them with *Able* upper stages for moon-orbit attempts;

• It could use the Air Force's larger version of the *Agena*, now under development, to conduct significant missions when it is ready.

The first of these two possibilities is remote (See M/R, Dec. 7, p. 30). Though the delivery date of the Convair *Atlases* for Project *Vega* is unknown, it is doubtful that it would have been before late 1960—when the first *Vega* engine was supposed to have been ready. And the *Atlas* delivery schedule can hardly be speeded up: lead time on an *Atlas* is 18 months—15 months under a crash program. By the time the *Vega Atlases* are available, the superior *Agena* engine should be ready to go.

The only other place that NASA could get an *Atlas* would be from the Project *Mercury* effort, or from the Air Force's missile and space programs. None of these possibilities are likely. (See M/R, Dec. 7, p. 31.)

It is therefore evident that NASA's cancellation of *Vega* left only *Agena* to do significant space work before the advent of *Centaur*.

• ***Agena's* specs**—**Lockheed's** *Agena* engine, as it is presently employed with the *Thor*, uses hydrazine and nitrogen tetroxide, and produces 15,000 lbs. of thrust. It can put a payload into a nearly circular orbit with its horizon-seeker guidance.

This capability does not compare with GE's *Vanguard* engine, which would have produced 35,000 pounds of thrust, and whose ability to start and restart in space, together with its guidance system, conceivably could have placed payloads into accurate circular orbits in the angle of inclination desired.

Though the *Agena* project is shrouded in military secrecy, informed sources state that the *Atlas*-based version of the vehicle will have increased thrust, will carry more fuel, and have a start-restart capability.

The only other available information about the *Atlas-Agena* is that it will fit into the 10-foot-diameter *Atlas* barrel the same way the *Vega* engine would have. This could mean that some of the work done to adapt *Atlas* for *Vega* will not be lost.

Present estimates are that the *Atlas-Agena* could put more than 3000 lbs. of payload into a nominal 300-mile orbit as opposed to the 5800-lb. payload capability for the same mission claimed for *Vega*. This means that NASA could use the Air Force vehicle for significant heavy-payload missions around the earth, and to the moon and beyond during 1961.

How many *Agenas* NASA intends to buy is not known. This may depend somewhat on how many of the six *Atlases* liberated by *Vega's* demise NASA will transfer to its new *Agena* account.

But if the late 1960 delivery date holds up, one specific mission NASA might use the vehicle for is a mission to Mars.

• **Mars shot**—The favorable astronomical time for such a shot is late 1960, and the *Atlas-Agena* is capable of such a mission. If it is not ready, the space agency will have to use a less adequate vehicle such as the *Thor-Delta* or *Atlas-Able* or wait many years until Mars makes its closest approach again.

Another use that the *Atlas-Agena* could be put to is an attempt to place **Space Technology Laboratories'** 375-pound payload in orbit around the moon. The earliest this shot could be scheduled would be early 1961—almost a year and a half after the *Atlas-Able*'s failure to perform this mission last month.

With the elimination of *Vega*, the NASA space vehicle lineup for the next five years is:

• *Scout*. A cheap, reliable, solid-propellant vehicle which can launch a 300-lb. payload into a 200-mile orbit. Under prime contractor **Chance Vought**, *Scout* is expected to cost $500,000 per vehicle and should be ready this summer. This vehicle will be the workhorse of low-altitude satellite orbit research.

• *Thor-Delta*. Capable of putting 65 pounds of useful payload in orbit around the moon and of rough-landing 50 pounds on the moon, *Thor-Delta* under STL management is expected to be ready next year.

• *Atlas-Agena*.

• *Centaur*.

• *Saturn*. The first space vehicle in the U.S. arsenal that will be capable of operational manned space flight. With a booster consisting of a 1½-million-pound-thrust cluster of eight **Rocketdyne** H-1 engines, *Saturn* can lift heavy manned stations into low orbits. It would allow the U.S. to put up a space communication center, a meteorological observation center, and a scientific research center. Under ABMA direction, *Saturn* can also launch large unmanned payloads into deep space and to the planets. With funding, it could be ready sometime in 1962.

• *Nova*. A cluster of 1.5-million-pound-thrust engines being developed by Rocketdyne, *Nova* could make a manned landing and return from the moon of a 2100-lb. payload, orbit Venus with a 15,000-lb. payload, or make an unmanned landing on Venus and return with a 4500-lb. payload. Estimated operational date is 1965.

Marines Taking *Cobra* For Evaluation Testing

WASHINGTON—The Marine Corps early next year will begin tactical evaluation and test firing of the *Cobra* anti-tank missile, which is already operational in the West German Army. **Daystrom, Inc.** has exclusive manufacturing and sales rights for the U.S. and Canada, and will produce *Cobras* at its Military Electronics Division, Archbald, Pa.

The wire-guided *Cobra* weighs only 20 pounds, warhead and all, and can be carried and set up by one man. The warhead carries 5.5 pounds of explosives—sufficient to penetrate the heaviest armored tank. Using solid fuel, it has a 1.8-mile range.

One guidance control unit can launch and control eight of the 30-inch-long *Cobras*. The four-finned, cruciform-shaped missile, four inches in diameter, has two sections—the body, which contains the receiver, and the warhead.

Probe Would Be Tracked 5 Months

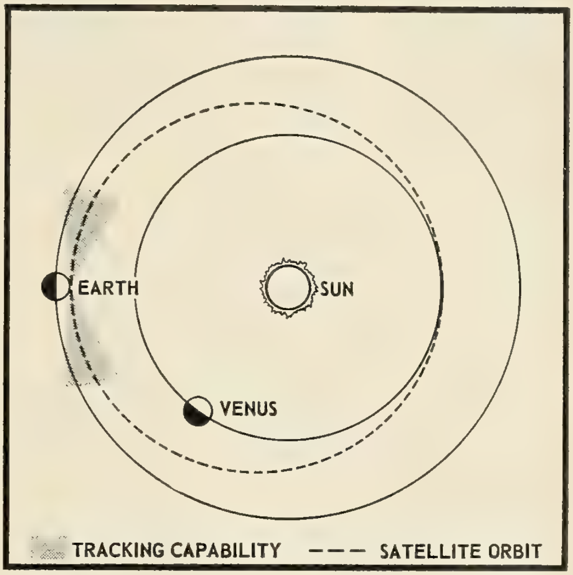
NASA's planned sun orbiter, Thor-Able IV, could stay within tracking range until May, expanding communication know-how and providing new information on solar system

WASHINGTON—The *Thor-Able IV* "Paddlewheel" satellite which the National Aeronautics and Space Administration planned to place in orbit around the sun Dec. 16 would permit ground tracking stations to keep in touch with its powerful transmitter for almost five months.

The 95 lb., 26 inch diameter payload (M/R, Oct. 19, p. 33), would be tracked out to 50 million miles or better, and if the payload obtains its programmed velocity and trajectory, it would not travel that far ahead of the earth until mid-May.

As was reported first by MISSILES AND ROCKETS, the payload has been designed to study interplanetary gas and solar terrestrial relationships. (M/R, Oct. 19, p. 33.)

Studies by Van Allen in earlier earth satellites indicated that the sun emits quantities of plasma gas into the solar system, some of which is captured by the earth's magnetic field to form belts of charged particles.



TRAJECTORY OF *Thor-Able IV's* trajectory should take it to the orbit of Venus at perihelion, and back to Earth's orbit at aphelion. Orbital period should be 280-300 days and its velocity in excess of 25,000 mph.

- **To study gas**—These streams or fields of gas would be studied by a one-pound search coil magnetometer developed by **Space Technology Laboratories,** which possesses a sensitivity of at least 10^{-5} Gauss. (M/R, Oct. 19, p. 33.)

The satellite would also study the magnetic fields of plasma globs floating through interplanetary space from the sun and try to determine the mechanism for the propagation and transportation of the plasma streams from the sun to the earth and into the rest of the solar system.

The satellite's instrumentation would also observe meteorites and dust particles in solar space outside the earth's gravitational field. And it would collect data on the sun's ultra-violet and X-ray regions, which when correlated with the plasma and meteorite information, should give a clearer picture of terrestrial relationships.

Specific instrumentation which would perform these tasks (besides the magnetometer) are a five-pound high-energy radiation counter which classifies radiation by how many tiny argon gas-filled cylinders the particle can penetrate, a micrometeorite counter, an aspect indicator which triggers electrical impulses each time it looks at the sun, a Gieger-Mueller tube which measures the total radiation flux encountered, a five watt and a 150-watt UHF transmitter, both of which operate on 378 MC.

Helping to transmit the information received by the satellite's instruments would be a compact telemetric digital unit developed by STL called "Telebit." Designed to transmit information over interplanetary distances upward of 50 million miles, this instrument collects, stores, and tallies data while the transmitter is off, and sends the totalled information by radio signal to earth when the transmitter resumes operation. (M/R, Oct. 19, p. 34.) The satellite will transmit information about five minutes every hour.

- **Astronomical unit**—A second mission would be to make a more accurate determination of the astronomical unit. Long-range communication with the satellite would allow scientists to make satisfactory triangulations with the satellite and the sun.

The solar-cell encrusted paddlewheels would be similar to *Explorer VI's* and *Atlas Able-IV's,* but apparently are smaller and carry almost half as many cells. The unit would get about the same power as *Explorer VI,* however, since it is travelling closer to the sun and it would get about one-third more solar energy.

Originally scheduled to go to Venus last June, the satellite would be the first attempt to orbit around the sun inside the earth's orbit, and may come close to Venus' orbit at perihelion. Time of orbit would be between 280 and 300 days.

Nest for a Bird: *Polaris* Container

BURBANK, CALIF.—Production men in **Lockheed's** facilities here are building the biggest and most durable bird's nests in history.

The "birds" are the Navy's *Polaris* FBM nearing operational readiness under Lockheed weapon system management. The nests: double-lined shockproof shipping containers designed for air, rail or truck transportation of the submarine-launched weapon.

Accommodating the three-story-high missile, the containers are built to precision standards yet are rugged enough to protect a shipment of eggs over a corduroy road without cracking a shell.

The pressurized containers are designed for repeated usage, protecting the entire missile from damage and temperature variation in transit or storage.

The double-sheath, double-strength containers weigh approximately 11 tons. Special product sales, which includes missile activity, will amount to about $12,000,000 in the division this year, and involves 700 employes.

Approximately $1 million in precision tooling is involved in the missile container program alone.

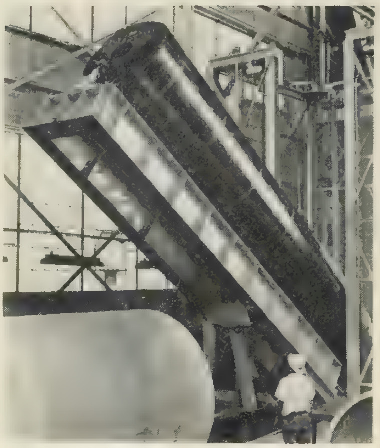
The inside portion of the missile's double container consists of a fiberglass inner liner incorporating electrical heating elements to hold uniform temperature during transit or storage, a two-inch foam plastic insulating layer, and a tough aluminum alloy skin.

Inflated air cushions between the inner and outer containers prevent jostling or vibration in transit from disturbing the missile's vital controls. The external container holds the entire missile.

The fiberglass lining, fitting over the missile body, is produced by **Zenith Plastics** on one of the largest plastic-impregnated tape wrapping machines in the United States; the pneumatic cushions are supplied by **Goodyear Tire and Rubber Co.;** and the foam plastic insulation material is produced by **American Latex Co.** under license from Lockheed.

Completely loaded, the missile is carried right to dockside or to the warehouse for "shelf storage," retaining its liner and inner container for protection until the bird is actually loaded aboard the Navy's new nuclear powered *Polaris* submarines.

The Burbank facility is constructing precision dummy missiles called "MFTV" bodies—for mechanical fit test vehicles—which are identical in size and weight to the actual *Polaris.*



DOUBLE-LINED shockproof shipping containers are designed at Lockheed for air, rail or truck transport of the FBM.

These units, built with optical tooling measured to an accuracy measured in thousandths of an inch, also are reusable. Produced for *Polaris* submarine-building shipyards to check the launching tubes of the actual submarines, the test units are speeding the *Polaris* to operational use by freeing actual missiles for test work while providing functional realism to shipbuilders.

Burbank plants also are producing *Polaris* "exit nose fairings" for the missile's escape from the earth's atmosphere in its ballistic trajectory, and launcher adapters providing a compressed air seal inside the launching tube for the missile's subsurface firing—thus doing a similar job to that of piston rings in an automobile engine for the weapon's initial launch phase.

Even With Gold, *Scout* 'Poor'

DALLAS, TEX., Dec.—Gold is helping to conquer the heat problem posed by space age rockets.

Chance Vought Aircraft, assembler of the National Aeronautics and Space Administration's *Scout* research rocket, uses more than 100 square feet of gold plating in the "poor man's" rocket skin. The rocket ultimately will cost $500,000 a copy.

The precious metal is gaining prominence in space vehicles because of its high heat reflectivity, relatively high melting point, low spectral emissivity and excellent corrosion resistance. It will resist melting up to nearly 2000°F.

The fourth stage of the *Scout* rocket has its inner skin gold coated to protect the scientific instruments from extreme heat caused by atmospheric friction. This plating is only .00001 of an inch thick and the gold costs only 60 cents a square-foot to apply.

Because the parts of the rocket requiring gold plating are so large the usual electrolytic and vapor deposition methods were not practicable and Vought went back to a process used centuries ago to apply gold coatings. A gold resinate soluable in pine oil is sprayed on the part to be coated. The part then is baked in an oven at 375°F for 15 minutes. The coating turns to pure gold in a second hour-long bake at 700 degrees.

Gold coatings also have another possible value for today's high performance aircraft, which radiate considerable infrared energy. Some antiaircraft weapons use infrared seeking devices to locate aircraft targets. For this reason, it is desirable to have the emissivity at all wave lengths as low as possible to reduce the possibilty of detection.

By preventing structural heating through use of gold coatings on the internal skin structure or shroud, the heat radiated from the engine to a plane's structure can be reduced substantially, lessening the danger of infrared detection. A sizeable reduction in costly shroud weight may also be realized by gold coating in the engine area.

In the case of the *Scout* missile, the problem was to protect the payload of instruments contained in the fourth stage from excessive skin temperatures generated by high Mach number flight into space. Vought applied a highly emissive ceramic coating externally to the rocket's skin to radiate friction heat back into the atmosphere. On the inside, the low emissive gold coating was used to reduce heat radiation to the payload.

Another use of gold in aircraft and missile manufacture is on printed electrical circuits and contacts made from copper. Gold is deposited on the copper by ionic decomposition. The .000002 inch thick gold coating on the copper is lightweight, economical and continuous. This method is used by Vought principally to extend the storage life of printed circuits and improve solderability by increasing resistance to oxidation and tarnish.

Computer Simulation of Lab Testing May Cut Costs

Expermits during component design indicate savings in time and money; CEIR's approach described

by Charles D. LaFond

WASHINGTON—Components reliability before integration into systems—the old bugaboo of the missile industry—may be solved by extensive use of high-speed electronic computers in the early R&D phase.

While it's too early to determine cost savings, experimental sampling during the design phase with computer simulation of laboratory testing offers promise of considerable economies in time and money.

A major problem in the development of a complex weapon or electronic system is the incredible amount of laboratory life-testing necessary before minimum reliability of each component is proved. While this is a problem, establishment of optimum tolerances during the much earlier design stage usually is even more troublesome.

System designers always face a basic problem in economics: What tolerances should be specified on each particular part to achieve the desired degree of system reliability?

Often, in designing a complex system, the engineer has to work backward from contractually specified total-system requirements to determine parts and subsystem performance tolerances. There's always the risk of overly tightening tolerance limits. Usually this is caused by design conservatism.

Extreme tolerances are injurious to the whole effort—components become costly and often unobtainable as standard items.

Result is over-engineering of vastly complex major weapon systems which imposes a burden on our military effort—already suffering from a tight budget.

- **Current policy**—The Air Force ballistic missile program is one good example of tackling the reliability problem. It has experienced certain success, but it has been costly. In defense of high cost is the urgency of national defense, although when started, the program lacked previous engineering experience.

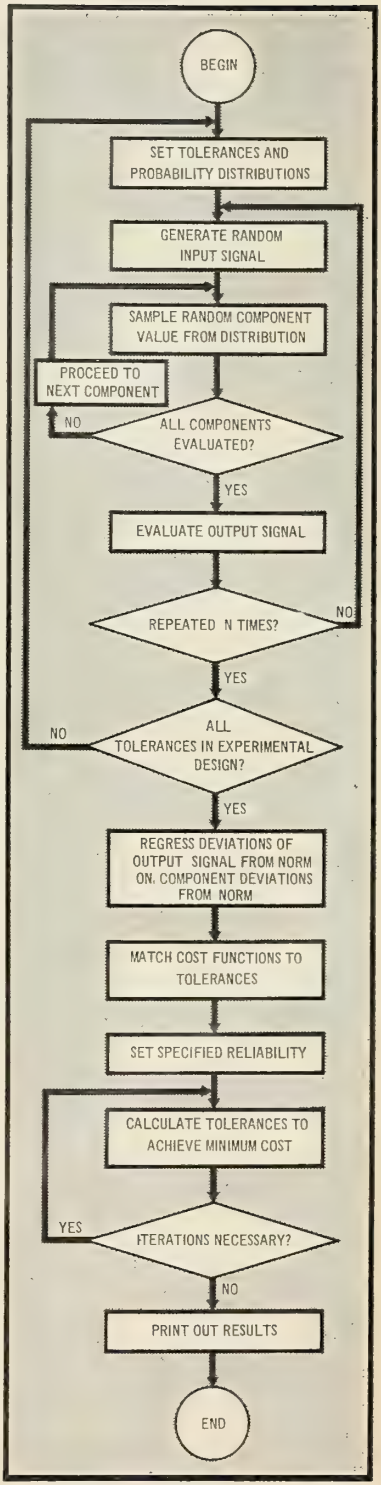
Because of program urgency, R&D time has been limited on each of the four major weapon systems: *Atlas, Titan, Minuteman,* and *Thor.* Air Force Ballistic Missile Division said lead time for R&D phases was less than half the normal time allowed for projects of similar magnitude and complexity.

In these programs, various phases of subsystem development were performed concurrently and with the spectre of previously defined reliability requirements covering each, hovering overhead. Normal developmental steps, however, were not compressed. As items met minimum acceptable reliability goals, they moved forward to the next phase of the program. Statistical data were amassed in the progression, providing meaningful information for determining initial total-system reliability.

One major premise in current military policy is that 100% reliability is not attainable and is even impractical as a design goal. For example, in a typical ICBM the design objective may be for a reliability of 0.97 for guidance, but this would be a final goal achieved long after the system had become operational. The initial operational capability would be assigned a minimum acceptable value of the order of 0.88.

But to achieve desired minimum reliabilities requires a tremendous effort in testing. Data processing machine simulation has not been employed generally as a design tool to reduce error and minimize the amount of testing required.

The technique has been used by many as an aid in modification. For


BEGIN
SET TOLERANCES AND PROBABILITY DISTRIBUTIONS
GENERATE RANDOM INPUT SIGNAL
SAMPLE RANDOM COMPONENT VALUE FROM DISTRIBUTION
PROCEED TO NEXT COMPONENT
NO
ALL COMPONENTS EVALUATED?
YES
EVALUATE OUTPUT SIGNAL
REPEATED N TIMES?
NO
YES
NO
ALL TOLERANCES IN EXPERIMENTAL DESIGN?
YES
REGRESS DEVIATIONS OF OUTPUT SIGNAL FROM NORM ON COMPONENT DEVIATIONS FROM NORM
MATCH COST FUNCTIONS TO TOLERANCES
SET SPECIFIED RELIABILITY
CALCULATE TOLERANCES TO ACHIEVE MINIMUM COST
YES
ITERATIONS NECESSARY?
NO
PRINT OUT RESULTS
END

SCHEMATIC computer simulation for determination of optimum tolerances.

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Astronautics Division. Concentrating on advanced vehicles for space exploration and on ballistic and anti-ballistic missile systems. Supplying four-stage *Scout* research rockets and launchers to NASA. Participation in the competition for the development of the *Dyna-Soar* boost-glide vehicle.

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example, **Norair Division of Northrop Corp.** used an IBM 704 extensively for redesign of the *SM-62A Snark* fuel system. Result was a vastly simplified system with a correspondingly higher operational reliability.

- **Computer solution**—Each complex electronic system used in a missile or rocket is composed of many parts and subassemblies known to interact in certain ways. Engineering considerations have resolved problems dealing with the nominal response of the system components to each of the various inputs that may come into the system.

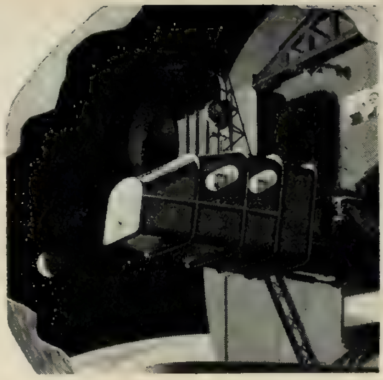
To achieve reliable operation, the input must be known and the output must be predicted within some specified degree of variation. Output may be a voltage having some nominal value, or it may be the presence or absence of an electronic pulse. If a voltage, specified bounds about the nominal value are indicative of successful operation. In the event that the output is a pulse, this pulse generally must exceed some threshold.

One organization that has used computer simulation to determine optimum tolerances is **CEIR, Inc.** (Corporation for Economic and Industrial Research of Arlington, Va. It has developed and used a technique that establishes tolerances on each of the individual components of a system to meet required total-system reliability at minimum component costs.

For efficient performance of such simulation, one condition is self-evident: The task must be a joint effort of the engineer or scientist having intimate familiarity with the system to be designed, together with a statistician, numerical analyst, and a programmer and coder. The engineer supplies system parameters; the statistician specifies what numerical results are necessary for analysis; the analyst specifies computational algorithms; the programmer and coder translate numerical procedures into machine language.

- **Data needed**—In the CEIR approach, certain basic statistical data are required, including cost-versus-tolerance curves for each of the components. These curves may be smooth continuous curves or they may be step functions, indicating that cost is constant over a range of tolerances, increasing by a discrete amount for another and smaller set of tolerances, etc.

In addition to the cost-versus-tolerance information, the theoretical structure of the system must be known precisely. That is, it must be possible to express the output as a function of an input signal and of each of the system components. This expression will take the form of some (generally) complex mathematical function. Reliability then is measured by the probability that the



VOUGHT SEES SPACE WITH A MAN IN IT

At Vought Astronautics, space and manned flight into space are coming steadily nearer.

In the Human Factors Laboratory, engineers and scientists operate earth-orbital simulators and space-capsule mock-ups as complete in cockpit detail as a production aircraft.

Company pilot-engineers have run up a total of more than 200 simulated orbital flights. In other studies, Vought space-medicine specialists are developing closed ecological systems to provide man oxygen, food and water for flights lasting months, years . . . generations.

Plainly, Vought Astronautics' interest in space centers around the men who will explore it at first hand, and around the man-carrying portions of their vehicles. This has been a natural step for the life-sciences engineers who gained so much experience on Vought's high-performance aircraft.

Through participation in the *Dyna-Soar* development competition, these men already have applied aircraft human-factors experience to space. In the matter of space-flight and navigation simulation, these men probably are farther ahead than any U. S. team.

A major Vought effort now is to determine which functions of space flight will be machine-operated and which will be entrusted to man. The answer very likely will come out of a simulator — one which duplicates the stresses of space flight.

Space is the specialty of Vought Astronautics. Other major interests are being aggressively advanced in the company's Aeronautics Division — where attention is on atmospheric missiles, antisubmarine apparatus and piloted aircraft — and in the Electronics, Range Systems and Research Divisions.

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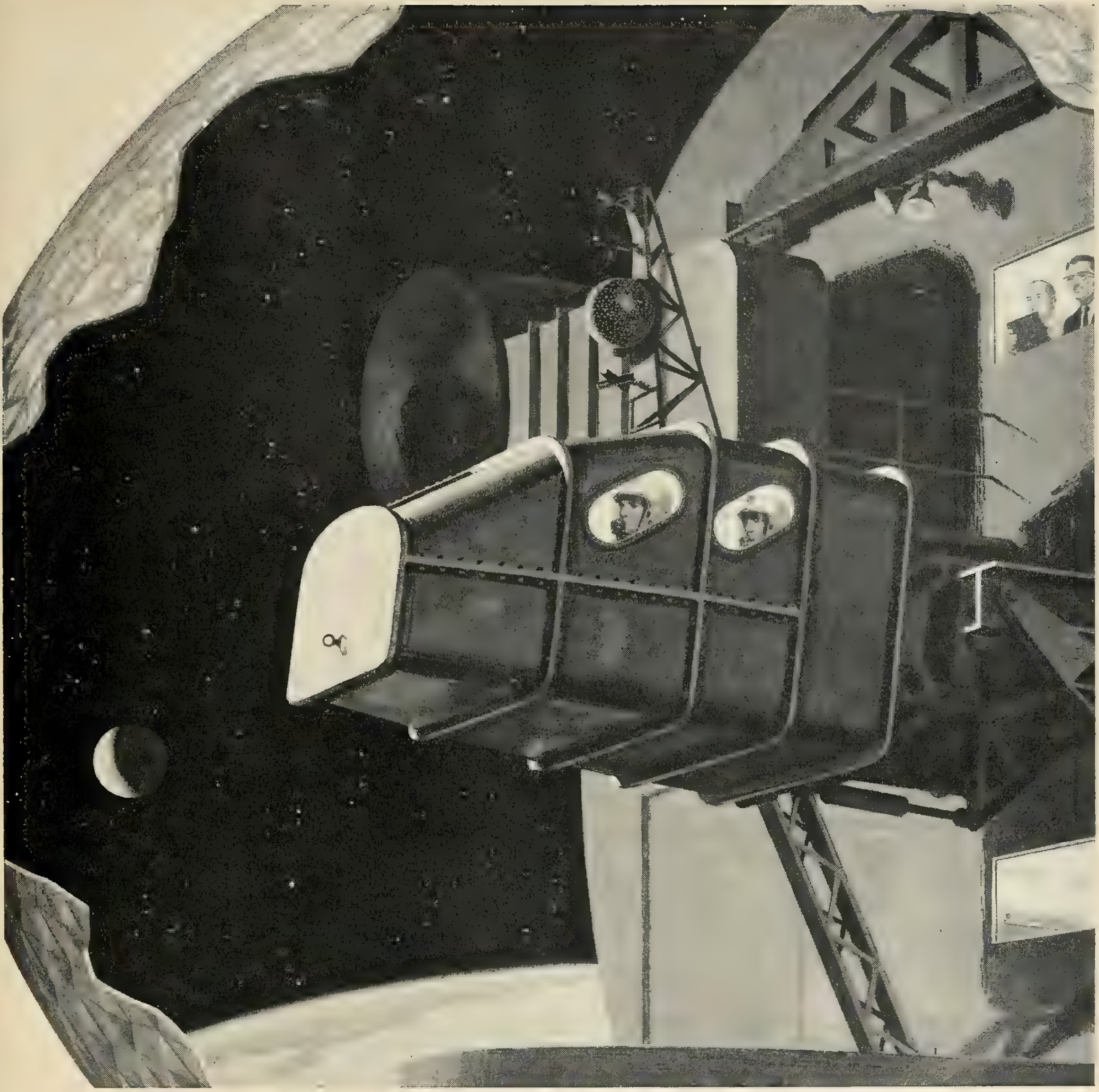
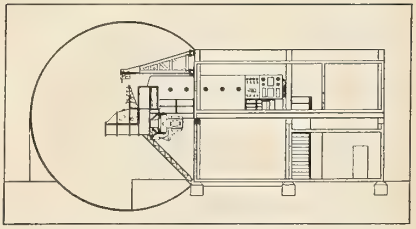


A PLACE TO IRON OUT THE STRESSES OF SPACE

Seventeen different stresses will flay the minds and bodies of the first spacemen. Under the combined attack of acceleration, anxiety, heat and other stresses, how will man perform? The answer probably won't be known until the problem can be simulated, in all of its parameters. Vought Astronautics — a division of Chance Vought Aircraft, Incorporated — is preparing the way with the proposed simulator above. Inside the laboratory's mock space vehicle, a man — without leaving the ground — would know the heat, movement, noise — and many psychological effects — of an extra-terrestrial voyage. He would glimpse a pitching, yawing close-up of the solar system. He would experience, altogether, an invaluable preview of combined stresses of space flight. Vought Astronautics can produce and operate such a lab now for the development of spacecraft and the training of pilots.



From active flight instruments, motion, and a planetarium projection — a realistic preview of space flight.

AERONAUTICS ASTRONAUTICS ELECTRONICS GENESYS CORP RANGE SYSTEMS RESEARCH

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output for a given set of inputs will be within certain specified limits.

The technique advocated by CEIR simulates random values of each of the components subject to some underlying probability law which may or may not be symmetric about the nominal value. Information must have been acquired either through experience or theory or through an informed assumption about this underlying probability distribution.

It might be added that the sensitivity of the final result to assumptions about probability distributions can be tested. The corresponding random response of the system is generated on the computer.

• **Cutting cost time**—At this point the programming effort begins to simulate required random values of individual components and insert into the underlying mathematical expression to derive a distribution of output values to some nominal input. The dispersion of the probability distributions can be changed to simulate changes in tolerances.

Experimental results are analyzed by means of a regression analysis. Making use of cost-versus-tolerance information, Lagrange multipliers are employed to obtain those tolerances which yield specified reliability at minimum cost. Wherever possible, full advantage is taken of internal symmetries in the system.

In essence, the computer simulates the arrival of the input signal and derives the output signal consistent with the random variations of the components that have been derived from their assumed probability distributions. Most important is the fact that changes in tolerances, interpreted as changes in the dispersion of the probability distributions, can be examined by additional computer runs without the cost or time of laboratory models, prototypes or breadboarding.

The final results in the form of suggested parts tolerances must be examined with reference to their availability and the practicalities of the real world. A further cycle of computations with some restrictive constraints placed upon certain tolerances may be required. Further testing in order to establish the sensitivity of the results to any assumed probability distributions would also be planned at this point.

The final result is an exhaustive list of components with associated tolerances which, if achieved, would insure overall system performance reliability at minimum cost.

The approach described was limited to "performance" reliability. To obtain a truly optimum-reliability system, both operating time and environment would have to be considered. These are both primary contributors to parts failure and parts or system degradation.

If data concerning operating time and environmental effects are available, these too can be inserted into the problem.

• **CEIR's growth**—CEIR provides data processing services in addition to scientific, industrial and economic research and consulting services.

Starting in 1954 with $20,000, a handful of people (with a vaultful of brains), a contract, and an overwhelming faith in the future of electronic data processing, the organization has grown rapidly.

Now grossing above $4 million a year, CEIR is planning nationwide expansion with the establishment of new facilities in New York, Chicago, Houston, and Los Angeles, according to Dr. Herbert W. Robinson, company president. Present staff of over 200 will be increased to some 1300 in two years.

Its facilities include IBM-704 and 709 computers. Three transistorized IBM-7090 machines are on order. CEIR probably will get one of the new (due 1961) IBM Stretch computers for its Los Angeles facility.

Part of the company's success is due to the very great cost of computing machines. Unless a manufacturer or research organization can keep its equipment busy through a large part of a 24-hour day, machine costs are not justified.

To be able to buy computer service for just hours or days can be a great asset to smaller companies. Large corporations buy services to handle their overload or for special problems, thus keeping their machines free for regular workloads.

Indicative of the nature of CEIR's highly exacting business is the unusually large number of personnel holding advanced degrees. Almost all the sciences and many of the arts are represented. To keep up with its growth, the company operates continuous courses in computer programming for trainees.

Alternate Basis Sought For Electrical Standards

WASHINGTON—The National Bureau of Standards—working to improve the accuracy of electrical measurements, measuring devices, and standards—is attempting to establish an alternate, more accurate foundation for the whole structure of electrical standards.

The basis for the new approach is an accurate capacitance measuring bridge and an accompanying calculable standard of capacitance developed last year. It will provide a check on the standard ohm and volt—the basis for determination of all other electrical units.

NBS Studies Electric Arc As High-temperature Source

WASHINGTON—Electric arc techniques as sources of stable, controlled gas temperatures up to 20,000°K are under study at the National Bureau of Standards.

The recently initiated program is geared to find simple and reliable methods of producing and measuring extreme temperatures—eventually leading to establishment of high-temperature standards.

In the electric arc, gas temperatures can be calculated from spectroscopic composition measurements. A device for maintaining a controlled electric arc in an atmosphere of any composition has been constructed.

Consisting of a stack of water-cooled copper washers alternating with electrically insulated bakelite washers, the arc burns in the center cylindrical core between electrodes at each end. Windows are provided for optical viewing and spectrographic analysis of the radiation from the arc.

Current research at NBS involves comparisons between photoelectric and photographic measurement methods, between observations from the side and along the arc axis, and among the effects of optical geometry, arc length, current and similar easily varied parameters to determine their importance to the precision and accuracy of temperature measurements.

The biggest experimental difficulty is in obtaining suitable high-intensity light standards for use in measuring the absolute intensities of the arc spectroscopic lines. As the research on arcs progresses, high-temperature continuum radiation standards are being improved.

An example of this is the development of a carbon tube blackbody heated directly by a heavy current. This seems promising as a constant radiation standard up to about 3000°K. Different construction materials may permit higher temperatures.

A high-pressure, free-burning arc is currently under fabrication. It may provide a suitable standard of continuum radiation corresponding to temperatures of 10,000°K or more.

Heavy Soviet Missile Edge Reported

by G. V. E. Thompson

LONDON—Soviet missile strength heavily outweighs that of Western Europe, according to a report by the Institute for Strategic Studies.

The Russians have about 100 principal missile bases and a missile arm of about 200,000 men, the report says, while the NATO command has, in being or on the way, seven IRBM bases—four *Thor* bases in Britain, two *Jupiter* bases under construction in Italy, and one projected *Jupiter* base in Turkey—each to be equipped with 15 missiles.

The Institute for Strategic Studies is the only non-governmental center in the Western world outside the USA devoted to a continuous study of the problems of defense and disarmament in the nuclear age. It had its origin in the Brighton Conference Association, founded in 1957 'to study defense policy in the present stage of the cold war, and to relate its findings to political and moral issues which govern public opinion in the Western alliance.'

During 1958, conversations between BCA and The Ford Foundation resulted in the Foundation providing an annual grant of $50,000 for three years to enable the work of the BCA to expand and continue. As a result, BCA was replaced by the present Institute, which operates on a non-partisan basis and is intended to serve an international purpose.

The 200,000 men in the missile arm are commanded, the report says, by an Engineer-General, who controls production of rockets and guided missiles and nuclear weapons, and is in charge of testing sites and operational units. The missile bases are along the Baltic coast (mostly around Konigsberg), between Lake Ladoga and the White Sea, in the Southern Ukraine, in the Carpathians, and in the Thuringian Forest in East Germany.

The main weapons listed are the *T-3* ICBM (range over 5000 miles), the *T-2* and *T-4 IRBM's* (over 1600 and 1000 miles respectively), and the sea-to-ground missiles *Komet* and *Golem* (95 and 310 miles). *Golem* can only be fired when the submarine has surfaced; *Komet* can also be launched whilst submerged.

• *Blue Water* **missile for West Germany?**—Britain has had little success so far in exporting its missiles. Its biggest potential market is West Germany, which has shown more interest in U.S. missiles, in particular *Hawk* and *Sidewinder*. However, the Federal Government in Bonn is now reported to be considering a new British missile, *Blue Water*.

Little information has been released about *Blue Water*, but it is understood that it will have a range of up to 80 miles and a maximum speed of 2000 mph. Manufactured by **English Electric**, it will have a nuclear warhead and be highly mobile.

• **Australia orders the** *Bloodhound*—The announcement about *Blue Water* followed shortly after news of another export achievement. The Royal Australian Air Force is to be equipped with the **Bristol-Ferranti** *Bloodhound* surface-to-air missile. This has been chosen after an exhaustive appraisal of all the anti-aircraft defense systems available in the free world.

Australia becomes the third country to adopt *Bloodhound*, which has been in service with Britain's Royal Air Force and has been chosen for use in Sweden. The weapon now in production is the Mk. 1 *Bloodhound*, propelled by two **Bristol-Siddeley** Thor ramjets and four **Bristol-Aerojet** rocket boosters. An advanced Mk. 2 version is in a late stage of development.

The missile trade between Britain and Australia is not all in one direction. The United Kingdom has bought 150 *Malkara* anti-tank missiles (developed at the Australian Government Aircraft Factory near Melbourne) and 30 of these have already been sent for acceptance trials in Scotland. The 200-lb. *Malkara* was adopted by the British Army despite the availability of several other anti-tank missiles developed by U.K. firms (**Vickers, Pye,** and **Fairey),** as private ventures.

In addition, Britain for some time has been receiving deliveries of the Australian pilotless target, *Jindivik 2B*, for use in ground-to-air and air-to-air missile trials. The initial order was for 50 *Jindiviks*, but an additional order for at least another 40 is now expected.

The *Jindivik* has proved very successful: although the design life was seven missions, the mean achieved last year was 14 flights, and one *Jindivik* has already made 40 flights.

Japan Getting More *Sidewinders*

by an M/R Correspondent

TOKYO—Fourteen *Sidewinder* air-to-air missiles were delivered from the U.S. Government to the Japanese Air Self-Defense Force early last month. Shipment of 90 more is expected by early 1960.

The missiles already delivered have been assigned to the Defense Force's experimental unit in Gifu and will be attached to F-86F and F-86D jet fighters for training and test purposes. Test sites for the *Sidewinders* to be imported next year have not as yet been made public.

Assignment of *Sidewinder* to the Air Self-Defense Force appears to mean that that force has gained the upper hand in the current interservice competition between air, ground and sea forces for development of guided missiles and establishment of a missile corps.

Three weeks ago, a rocket corps was established in the Anti-Aircraft Gun School of the Japanese Ground Self-Defense Force in Shimoshizu, Chiba Prefecture, on the outskirts of Tokyo. This corps is in charge of testing the guided missiles to be test-produced by the Japanese Defense Agency's Technological Research Institute, and later will become the nucleus of the missile corps.

By the end of 1965, four *Nike* and four *Hawk* battalions are expected to be formed under the Defense Agency's second defense build-up program. The program goes into force on April 1, 1960.

The Maritime Self-Defense Force has a three-year program for building a missile destroyer of 2500 tons displacement. It will be fitted with *Tartar* launching pads.

The missile research program, currently being pushed by the Defense Agency's Technical Research Institute, has made a number of advances recently. The first air-to-air missile will be attached to jet fighters in the near future, and mass production is reportedly scheduled to begin about 1960.

Tullahoma Tunnel Testing Booms

TULLAHOMA, TENN.—As every airframe maker knows, it is cheaper in money and may save lives to test a vehicle in a wind tunnel. This is why the huge tunnels at Arnold Engineering Development Center here operate every night and are booked up for many months in advance.

Among the programs involved in recent tests here are the Air Force *Titan* ICBM, the Army *Sergeant* battlefield missile, the Navy *Polaris* FBM, and Project *Mercury* of the National Aeronautics and Space Administration. A full-scale *Sergeant* was tested. The others were scale models.

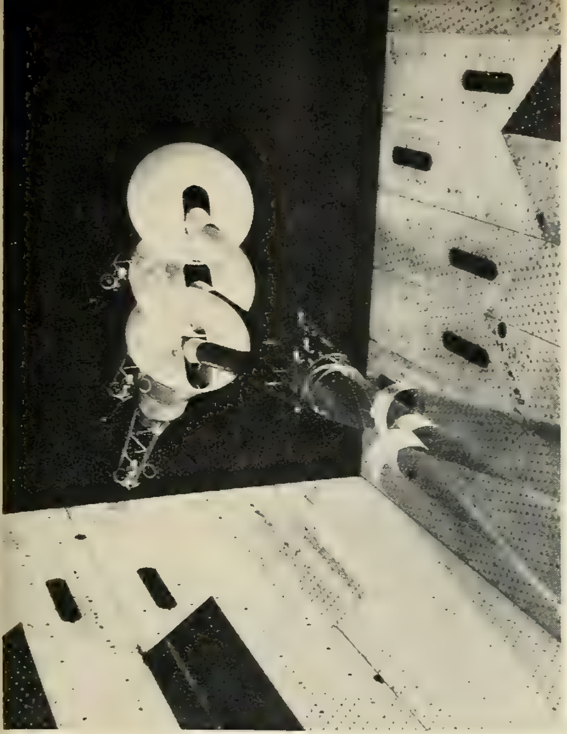
Testing at Tullahoma is done at night because of the amount of electricity consumed—a significant part of the output of the Tennessee Valley Authority. If it were done by day the cost would be much higher.

The Air Force located the center here 10 years ago on a secluded spot on an unused government reservation that had been a teeming Army infantry camp (Camp Forrest) during World War II. Isolation is necessary because the noise made by a big wind tunnel in operation is enough to shake the rafters of a house many miles away.

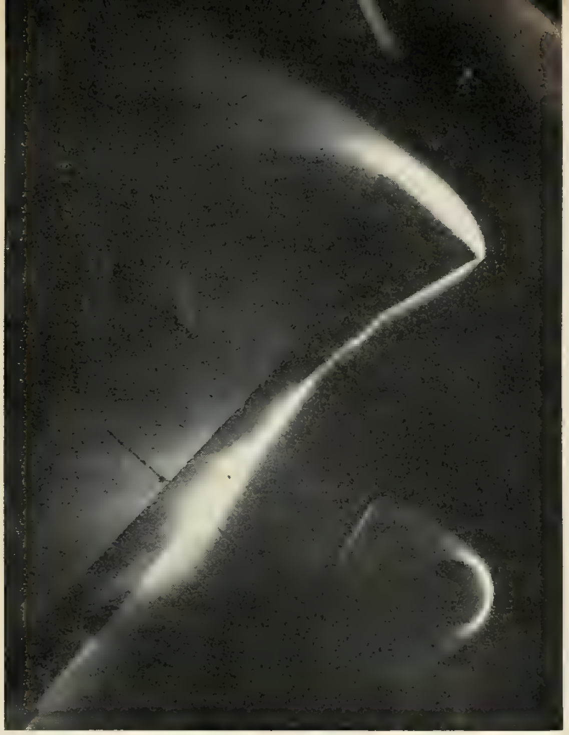
The problem that keeps AEDC engineers busiest nowadays is simulated altitude testing of rockets and missile components. For example, a rocket engine generating about 15,000 lbs. of thrust was tested successfully last summer at a simulated altitude exceeding 100,000 feet. This was the first time a rocket of this size had been tested under such extreme conditions. Early this month about 200 representatives of the services, industry and scientific organizations held a two-day symposium here on simulated altitude testing.

***TITAN* ICBM, in 11.5%-scale model, is installed for transonic test runs in the 16-foot test section of the Propulsion Wind Tunnel at Tullahoma. Inset is a frame from a motion picture film showing the missile with its rocket operating during a test run at the 10-year-old Arnold Engineering Development Center.**

FULL-SCALE flight-type *Sergeant* missile, about 30′ long, is installed for transonic test program in the 16′ Propulsion Wind Tunnel at AEDC. Such tests illustrate

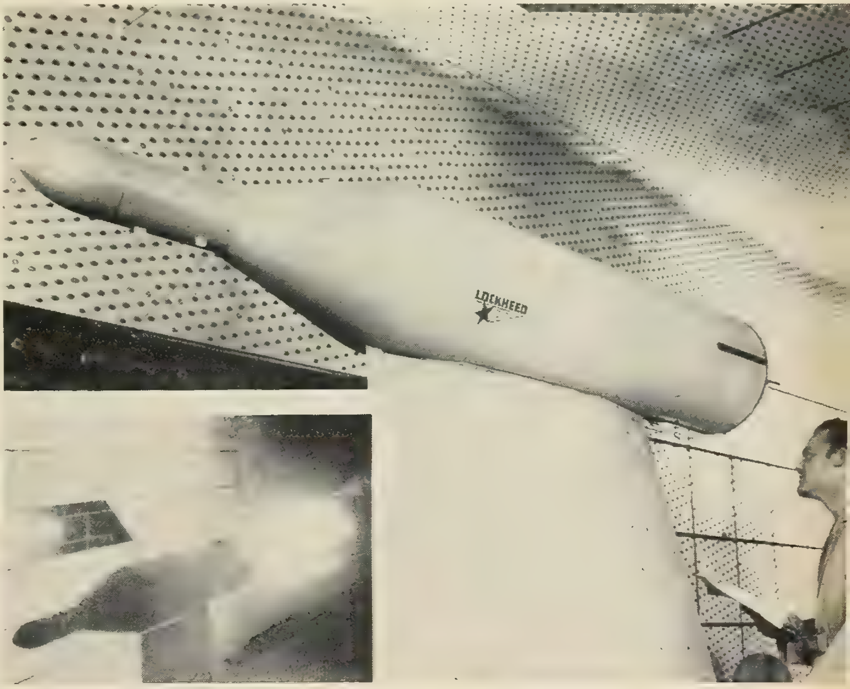


MULTIPLE-EXPOSURE photograph shows a 32% scale model of *Mercury* space capsule, with escape tower attached, on a movable support in the 16′ transonic test section of PWT. Tests were made from Mach 0.5 to 1.5.

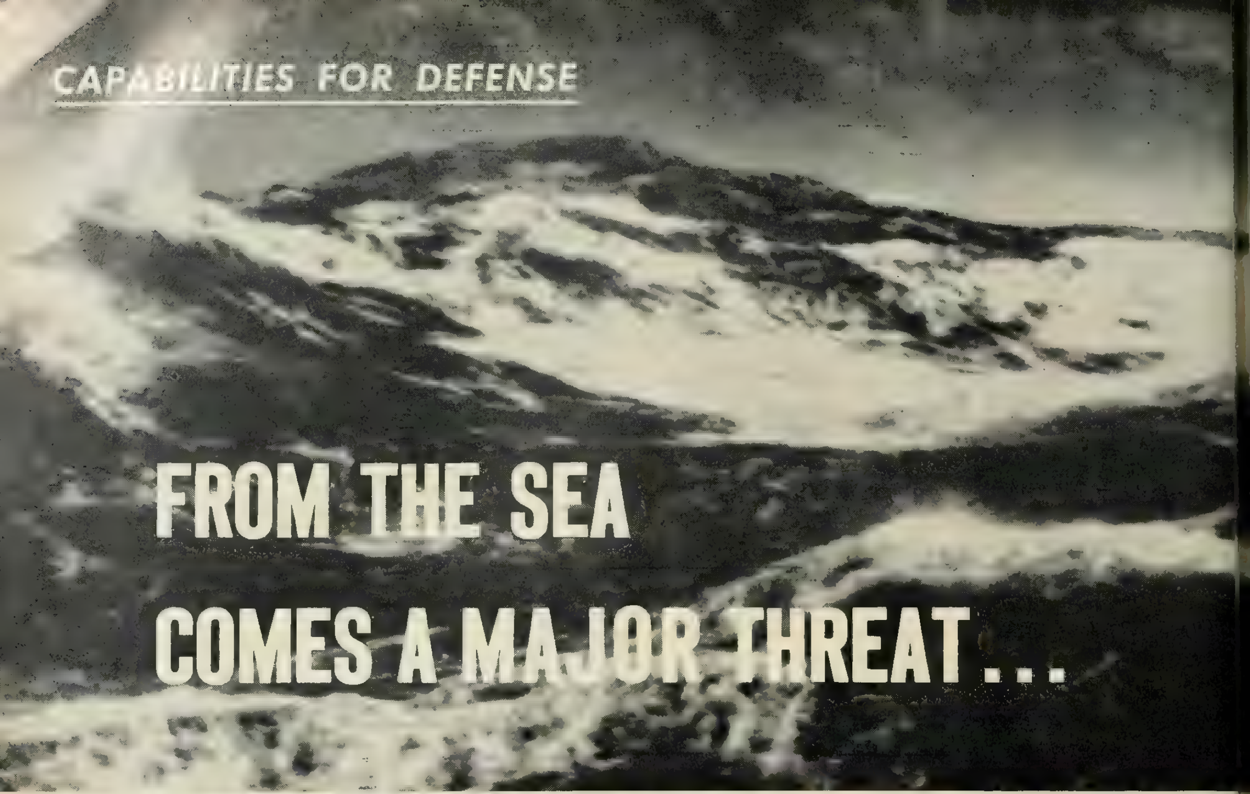


HYPERSONIC airflow is shown striking *Mercury* capsule at 50° angle of incidence. Mach 20 airflow became incandescent during test lasting 0.1 second, which determined stability and heat transfer characteristics.

value of large wind tunnel for critical aerodynamic measurements difficult to obtain by using small-scale models in smaller tunnels.

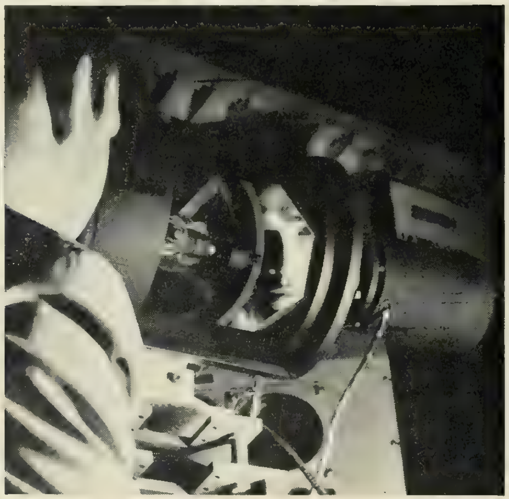


POLARIS **fleet ballistic missile** is tested in 1/5 scale model in the 16′ section of the PWT. Inset shows the flaming exhaust from the rockets. Although *Polaris* is solid-propelled, tests were made with both liquid and solid motors. Tests with liquid motors allowed for longer runs.



CAPABILITIES FOR DEFENSE

FROM THE SEA COMES A MAJOR THREAT...



The environment of the sea favors the submarine. This makes antisubmarine warfare—from detection to kill—one of the most formidable tasks faced by the U. S. Navy. Missile-firing nuclear subs further complicate this acute defense problem. ASW calls for all the imagination, skill and resourcefulness that industry, in its assisting role, can bring to bear.

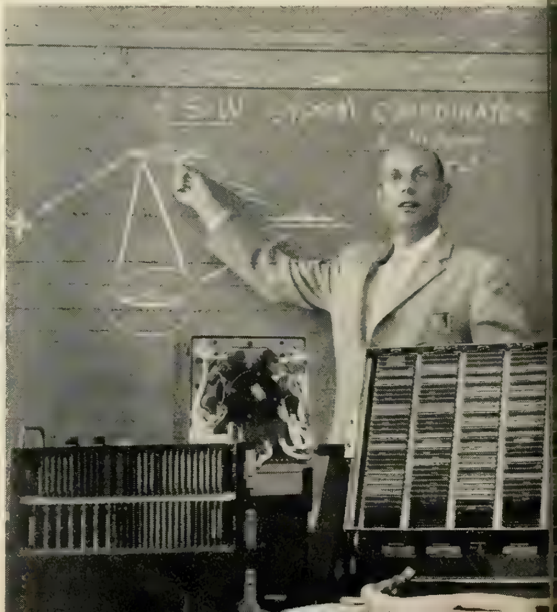
Westinghouse is engaged in a program to help our forces deal with this increasingly urgent challenge. The corporation's facilities—from research laboratories to manufacturing divisions—are working to help solve this threat.

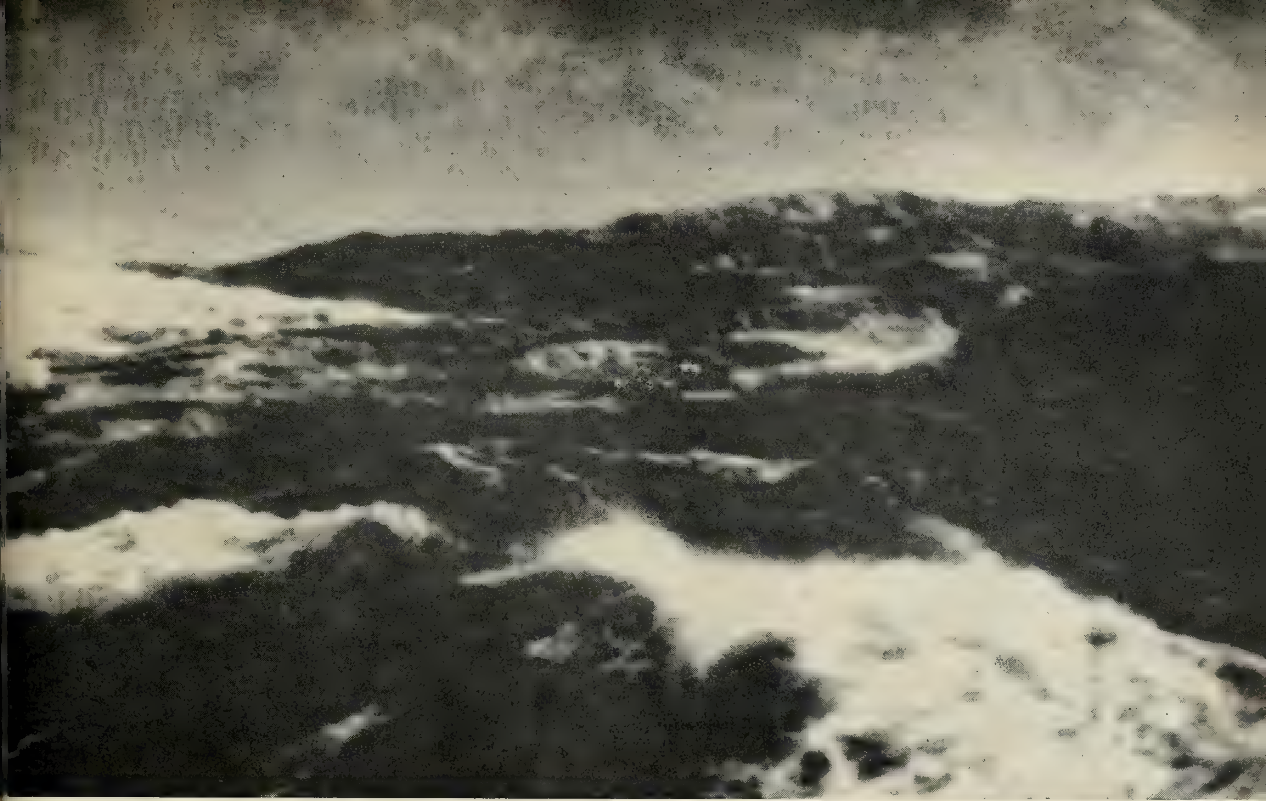
FLEXOLON wire by Tensolite Insulated Wire Company, Inc., is used in many systems developed at the Westinghouse Air Arm Division.

A BROAD WESTINGHOUS

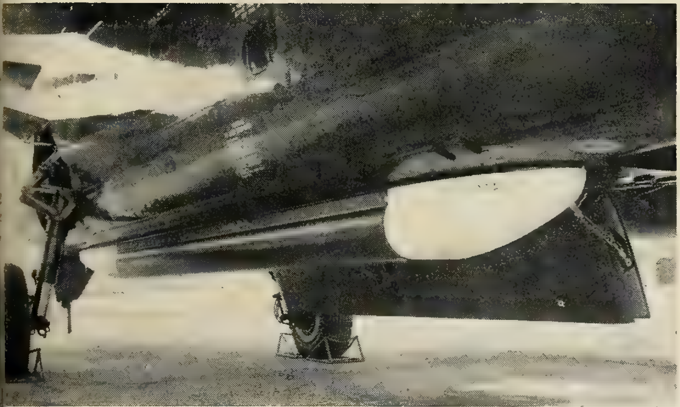
IMAGINATION: Westinghouse developments in scanning syste cells and special circuitry make possible detection of submarines i tactical environment.

Developments in computer techniques and components provide means for fully integrated ASW weapon systems, assuring early tection and sure kill. Typical is this new digital computer from Westinghouse AIR ARM DIVISION.





ASW PROGRAM IS HELPING TO MEET THIS MENACE



SKILL: New radar equipment is in the design and test stage at the AIR ARM and ELECTRONICS DIVISIONS. These Westinghouse radar developments will add effectiveness to ASW search and detection operations in a manner and to a degree never before achieved.

The precision-guided ASTOR torpedo system, provides a powerful weapon in effectively attacking enemy submarines. The ASTOR was designed and built for the Navy by the Westinghouse ORDNANCE DEPARTMENT.

RESOURCEFULNESS: From Westinghouse RESEARCH LABORATORIES comes special knowledge needed for the ASW program. An example is fundamental work aimed at understanding underwater sound "scatterers."

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Curtiss-Wright Makes Expendable Drone

by **Frank G. McGuire**

SANTA BARBARA, CALIF.—A low-cost, expendable target drone for use with air- and ground-launched missiles has been developed by the Santa Barbara Division of **Curtiss-Wright Corp.** The Air Force has awarded the company a $470,000 production contract for the bird, designated *SkyDart* TDU-12/B.

The rocket-powered drone now is being used primarily with *Sidewinder* missiles, and employs that weapon's launch rail and umbilical connector. The *SkyDart* features simplicity, high performance and low cost—since it can be manufactured for less than $2000, it is rated by the company as expendable.

The 80-inch-long target, 6.4 inches in diameter, is built around a single-chamber, dual-thrust rocket motor originally developed for the now-defunct *Dart* antitank missile. This motor forms the main structural portion of the target, and produces 620 pounds boost thrust for two seconds, then 75 pounds sustainer thrust for 44 seconds. Grain consists of ammonium nitrate bound by a synthetic rubber compound, and is divided into a large burning surface boost phase, and radial burning surface sustainer phase. Motors have been supplied by **Grand Central Rocket Company** and **Hercules Powder Company.**

• Specs exceeded—The Curtiss-Wright specifications were for a target that could be launched between 40,000 and 60,000 feet at speeds between Mach 0.8 and 2.0, with a useful endurance of 90 seconds while maintaining an altitude of ±5000 feet from launch altitude, and a maximum azimuth angle deviation from launch of ±5°. Tests of the bird showed many improvements on these specifications, including an actual endurance of 110 seconds, with maximum course deviation of less than 1° during a 30-mile trip downrange.

A canard-type vehicle, the target has two small adjustable control surfaces between nose and center section, preset for desired trajectory in the pitch plane. Main lifting surfaces are mounted in cruciform arrangement around the tail cone.

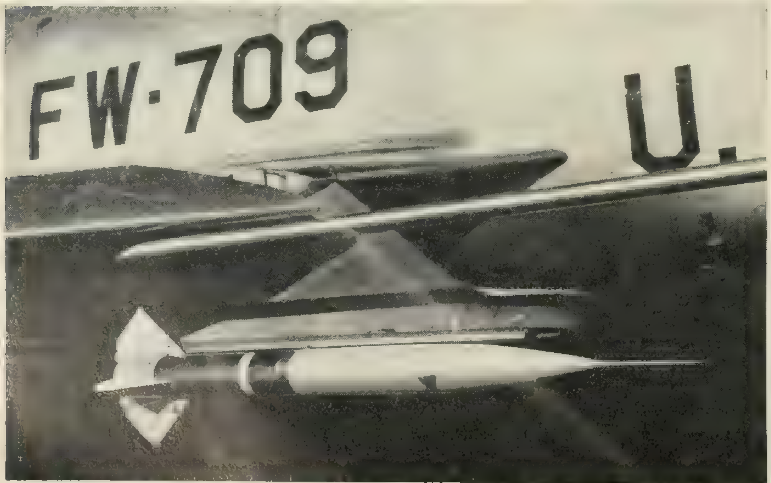
The *SkyDart* is roll-stabilized, maintaining level flight through two flippers comprising the outer panels of the vertical fins. These oscillate at a given frequency and achieve roll control through dwell-time modulation.

The autopilot translates signals received from the position roll gyro into corrective control surface action through electronic differentiation.

Manufactured by the Santa Barbara division, the autopilot consists of a printed circuit design with plug-in modules. Power is supplied by a 28V battery with a useful life over three minutes. The gyro is spring-wound and actuated by a pyrotechnic cartridge. Its useful life is also over three minutes, and it has a maximum drift rate of one degree per minute.

The forward section of the target is connected to the head cap of the rocket motor, and consists of a cylindrical payload compartment 18 inches long, to accommodate radar augmentation gear, telemetry equipment or self-destruct devices. Installation of a transponder would make the *SkyDart* useful with missiles other than *Sidewinder.*

Curtiss-Wright is adapting the *SkyDart* for ground launching to act as a target for missiles like *Hawk, Nike, Talos* and *Terrier.* A super-*SkyDart* target drone also has been proposed.



DUAL-THRUST rocket motor powers C-W's expendable *SkyDart* TDU-12/B drone. Supersonic vehicle costs about $2000 per copy.

Simplified Military Rockets

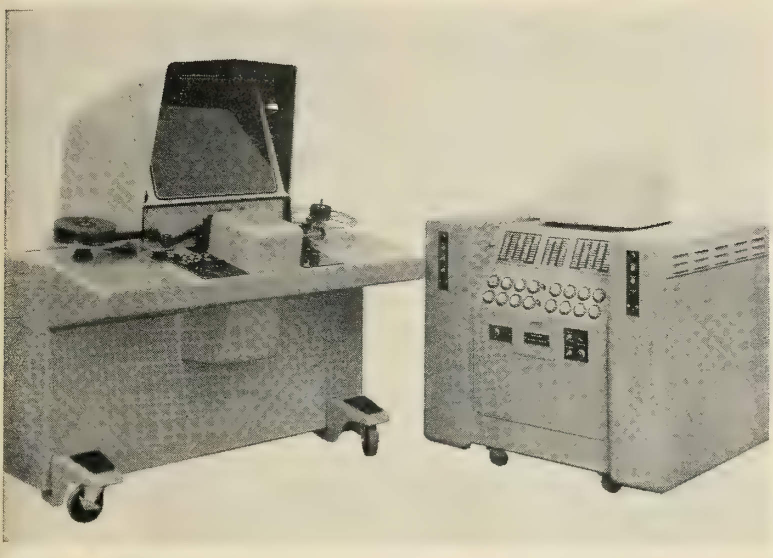
LONDON—Lieut.-Col. L. V. Stewart Blacker is advocating simplification of military rockets; he considers that for many targets artificial guidance is not needed. Absence of guidance would greatly reduce the man-hours required for design, development, production and testing of the missile, and would also lead to an improvement in reliability.

Blacker claims that the rocket he has designed will fly truly and in a manner free from errors due to irregular burning, etc. His invention is covered by British Patent Specification 773,190.

The principal feature of the invention is that the nozzle is not situated at the extreme tail, as in the conventional (and classical) rocket. Other drives have been tried, of course. Goddard experimented with nozzles near the nose without much benefit, and more recently Hickman was able to reduce dispersion considerably by building rockets with several nozzles, with thrust axes coinciding at the centre of gravity.

However, the "turning point" about which the missile tends to turn when the thrusts are out of balance does not coincide with the centre of gravity. The turning point is a function of both the centre of gravity and the centre of pressure. If all the axes of the nozzles are arranged to meet the turning point, any irregularity in burning or nozzle fabrication will be automatically compensated.

In practice, the thrust axes would be arranged to converge slightly behind the turning point, to take account of tolerances. They must not meet in front of the point. The angle of convergence need not be large, but depends on individual design requirements. The multiple nozzles are well in front of the tail stabilizer, which is not rotated.



Film Reader Automatically Digitizes

A semi-automatic film reader with an automatic, high-speed electronic digitizing unit which measures distances along two axes on 16mm to 70mm sprocketted film, has been produced by **Data Instruments,** a division of the **Telecomputing Corp.**

The Dilog 510 displays a magnified image of the film being measured. The digitizer is an indicating and recording accumulator which counts and stores measurement pulses generated by the reader. These counts are displayed visually, or may be read out on electric typewriter, punched cards, perforated tape or x-y plotter.

The reader has a counting rate of 20,000 counts per second with a maximum storage of 100,000 counts along each axis. Card punching speed is 50 cards per minute, and it will also type up to 600 characters per minute, or will provide 20 columns per second of punched tape with optional output equipment. The optical system provides the operator with a resolution of up to 60 lines per millimeter.

The film reader has a power requirement of only 8 amperes at 110 volts ac. The reading unit is 52" high by 53.5" wide and 36" in depth. The separate digitizing unit is 32" high by 38" wide and 33" in depth. All controls are located to insure minimum fatigue and maximum convenience for a seated operator.

Circle No. 225 on Subscriber Service Card.

Digital Unit Compares Command/Feedback Signal

United Aircraft Corp's Norden division announces an electronic device which performs continuous digital comparison of command and feedback signals and produces an accurate analog drive signal.

Two models of the Comparatron are available—one accepting up to two 24-bit parallel binary numbers, and the other up to two 24-bit parallel binary-coded decimal digits. Input data may be presented from a storage register, handset switches, or shaft encoder. By a process of digital comparison, an error-modulated ac output is produced for direct use as the positioning signal.

The company reports an inherent accuracy of within ±½ the least significant digit or bit, high-speed comparison, proportional error signal up to a predetermined saturation level, and compatibility with standard resolvers and servos.

Either model may be purchased with or without integral power supply. The output signal is a 60-1000 cycle (dependent on power supply) error modulated ac voltage with an amplitude of 23 mv peak-to-peak per unit error for the pure binary model and 15 mv peak-to-peak per unit error for the binary-coded-decimal model. Saturation level is at 100 units for the binary-coded-decimal model and 64 units for the pure binary model while saturation amplitude is 1.5v ac peak-to-peak at approximately 5K impedance. Required dc voltages are available from Norden Model 24A power supply. AC input required is 115 ± 10v 60-1000 cycles.

Construction of Comparatron is modular, each digit handled by a separate transistorized circuit board. The size of either model with or without integral power supply is 6 1/6" high x 22 9/16" wide x 18" deep.

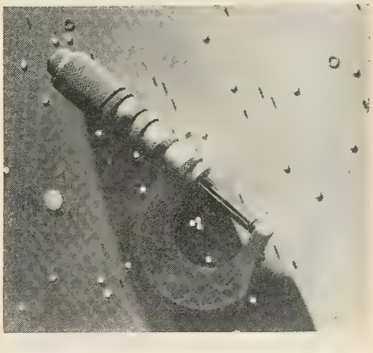
Circle No. 226 on Subscriber Service Card.

Molybdenum Stampings Used for Transistor Base Tabs

Gold-clad molybdenum stampings are now available to the semiconductor industry from **Accurate Specialties Co.,** for use as base tabs for silicon transistors and diodes.

Molybdenum has been found a suitable base tab material for silicon semiconductors since it matches the thermal expansion rate of silicon closely, exhibits good high-temperature properties, and has excellent thermal conductivity. Gold is used to permit easy soldering and because it can withstand subsequent etching operations in the semiconductor manufacturing process.

Accurate Specialties Co., Inc. has combined both of these materials in a single composite stamping consisting of a thin overlay of gold metallurgically bonded to a thicker base of molybdenum. This permits easier assembly in the device and allows a smaller package. Since oxidizable surfaces are reduced, semiconductor manufacturers can expect greater yield using this composite stamping.



The gold-clad moly stampings are available in diameters from .030" O.D. to .250" O.D.; in thicknesses down to .002", and with tolerances held as close as plus-or-minus .0001" on thickness. Delivery runs two to four weeks from receipt of order in lots of a million or more.

Gold-clad moly stamping also have

other possible uses in the chemical and missile industries where the user would like to use molybdenum at elevated temperatures in oxidizing atmosphere. The protective coat of gold on the moly part would permit its use in this application.

Circle No. 227 on Subscriber Service Card.

Actuator Made to Prevent Premature Air Launching

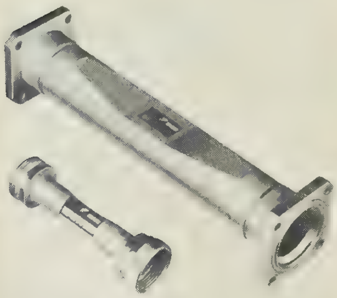
An actuator developed by Bendix-Pacific division of **Bendix Aviation Corporation** prevents the premature launching of a missile from its airplane cradle.

The mechanism, called a Geneva-Loc linear actuator, weighs 1¼ lbs. Electrically powered and mechanically positioned, the actuators are said to eliminate the need for clutches, brakes and limit switch adjustments through a pin-and-slot design, reducing maintenance and boosting efficiency.

Circle No. 228 on Subscriber Service Card.

Waveguide Unit Transforms Linear Waves to Circular

The **DeMornay-Bonardi Corp.** is producing a line of cylindrical waveguide components which transform linearly polarized waves to circularly polarized waves. Units are used with the corresponding size of rectangular waveguide. Cylindrical components cover the same frequency ranges, and exhibit the same broadband characteristics as equivalent D-B components.



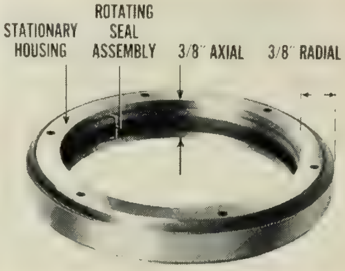
Three items are available. The first is a rectangular-to-cylindrical transition used to launch a TE_{11} mode of great purity in a cylindrical waveguide. The second is a circular polarization phase shifter used to transform a linearly polarized TE_{11} mode in a cylindrical waveguide to either left- or right-hand circular polarization. The third is a conical horn which radiates or receives either a linear or circularly polarized wave for antenna testing. By using the phase shifter in groups of four, a means is provided for continuously changing phase through as many full cycles as desired.

Sizes cover 5.85 to 90 kmc/sec. Among new applications for these cylindrical components are uses in plasma diagnostics. The different behavior of circularly polarized radiation is employed to derive information on the interaction of plasma with a magnet field.

Circle No. 229 on Subscriber Service Card.

Shaft Seal Withstands 30 psi Differential

A self-contained mechanical seal suitable for temperatures to 450°F that resists pressure differentials in one or both directions to 30 psi at shaft speeds to 15,000 s.f.m. is announced by **The Universal Grinding Corp.**



The compact seal design requires only about ¼ the axial space usually needed for seals of this type. The units frequently will fit existing lip-seal cavities without alteration, so that they are suitable for replacement where more efficient sealing is required. Available for shaft sizes from ½" to 8" diameter, UGC Seals are said to retain water, gases, and any type of lubricant with viscosity ranging from kerosene to heavy greases.

The enclosed seal assembly revolves with the shaft with a two-point static shaft contact so that shaft scoring or wear is not possible, the manufacturer states. This arrangement is said to eliminate need for costly superfinished shafts, and at the same time compensates for normal end play and whip. The completely self-contained UGC Seal is designed for press fit in the housing cavity. Need for customer-furnished seal rings, outboard washers or special retainers is eliminated.

The unit incorporates a rigid enclosure for the revolving assembly. A spring-loaded split grip ring transfers rotation from the shaft to the seal assembly. Primary seal is accomplished in the contact between a specially ground face on the carrier and the polished side plate. To achieve high sealing efficiency, the mating surfaces are lapped flat to within two light bands.

Heat transfer is achieved with pressure relief vents in the side plate on the wet side. Action of the revolving seal assembly causes the lubricant drawn into the seal to be recirculated under centrifugal pressure back out through the pressure-relief vents.

Circle No. 230 on Subscriber Service Card.

Cathode Ray Tube Has 3000-line Definition Range

A lightweight cathode ray tube capable of high resolution under standard circuit conditions has been made available to manufacturers of military and industrial equipment by Sylvania Electronic Tubes, a division of **Sylvania Electric Products Inc.**

The five-inch tube, designed for high-resolution photographic recording, has a definition range of 3000 lines with a spot size of .0013 inches at currents of five micro-amps.

The tube's electron-optical system and fine-grain screen achieve extremely fine trace width with conventional focus and deflection units and a simple beam centering magnet.

Designated type SC-2782, the new Sylvania tube has a flat, clear non-browning optical glass faceplate for optimum photographic quality. An integral encapsulated high-voltage connector is employed to minimize corona at high altitude. The tube is aluminized and uses a non-ion trap construction with magnetic deflection and focus.

Circle No. 231 on Subscriber Service Card.

Line of Low-speed Digital Test Equipment Available

A line of coordinated low-speed Digital Test Equipment "building blocks" has been announced by **Digital Equipment Corp.**

The "3000 Series" fits many low-speed digital applications where price and utility are important and is suitable for educational use, both in classroom demonstrations and in laboratory experiments, and for process control research and development involving digital techniques.

Units in the 3000 Series operate at

speeds up to 500 kilocycles, and are compatible with the company's high-speed units, since both employ the same logical techniques. Prices on the low-speed units average about half the cost of the comparable high-speed units.

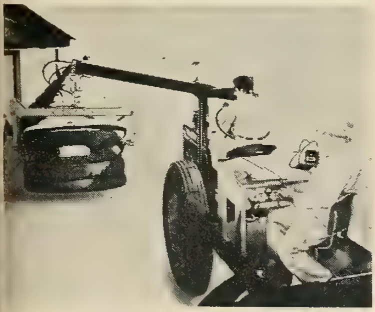
All logical interconnections are made with banana-jack patch cords on the front panels, and standard power connections are made through the plug-in back panels. Consequently the units can be readily assembled and reassembled for a variety of test and logical design applications.

Circle No. 232 on Subscriber Service Card.

Electric Hoist Scale Made for Support Vehicles

An electric hoist scale for use on lift trucks, warehouse tractors, and other materials-handling vehicles has just been announced by **Gilmore Industries, Inc.**

The M116 is composed of (1) two strain gage load cells, (2) an amplifying box which steps up the electrical impulse coming from the load cells, and (3) a digital type indicator (similar to that on a gasoline pump). Power from the scale comes from the vehicle's regular 6 volt dc battery.



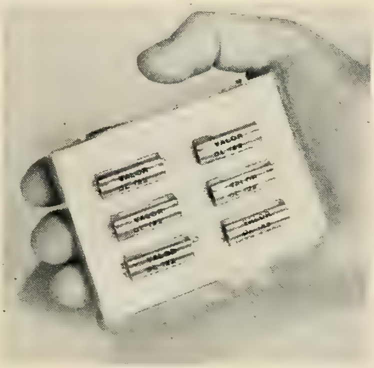
According to the manufacturer, since the M116 is both portable and mobile, the operator can move the scale to the material to be weighed, whether it is cotton, pulpwood, metal, or any other bulk or angular material. The manufacturer also says the instrumentation is sealed against dust, moisture, and temperature variations—and is rugged enough to stand movement over rough terrain. The weight indicator can be placed wherever it is most convenient for the operator.

The M116 can be supplied in capacities ranging from 1000 to 100,000 lbs. Accuracy of a 1000 lb. model is ± 1 lb.

Circle No. 233 on Subscriber Service Card.

Smallest Package Claimed For Six Lumped Delay Lines

Six lumped constant delay lines with delays of 0.1, 0.14, 0.2, 0.3, 0.5 and 0.7 microseconds are available from **Valor Instruments, Inc.** Each delay line has a 3 to 1 delay to rise time ratio and is molded in a 0.4" x 1" hermetically sealed brass tube with a fused tin plate finish. The company claims that the package is the smallest in which lumped constant delay lines are available.



Subminiature powdered iron toroidal inductors and temperature-compensating ceramic disc capacitors are used in the construction of these phase- and frequency-compensated delay lines. The delay lines are designed for transistor and printed circuit applications.

Circle No. 234 on Subscriber Service Card.

New Acoustic-Noise Test System Developed

Associated Testing Laboratories, Inc. has developed a new acoustic-noise test facility to duplicate the high-intensity sounds found in the proximity of high-thrust jet and missile engines.

This equipment will be used to evaluate the ability of missile and aircraft components and systems to operate and function properly in simulated flight conditions. It will produce sound pressure levels up to 150 decibels' overall intensity within eight controllable octave bands covering a frequency range of 37.5 to 9600 cycles per second.

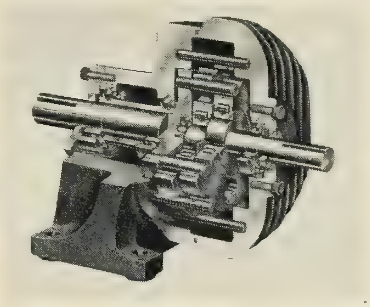
Designated Model AN-RV-15, the test facility includes a 15-cubic-foot chamber which accomodates test specimens up to 44" long. Larger chambers are now being built.

Circle No. 235 on Subscriber Service Card.

Cycloid-type Reduction Drive Is Introduced

A reduction drive based upon the cycloid principle of speed reduction is now being manufactured and distributed by **Black Tool, Inc.**

Because of the cycloid design, these HI-RANGE drives are 40% to 60% smaller than other types of reducers with comparable ratings. They provide a wide range of torque which ranges from about 30 in.-lb. torque per pound of reducer weight to over 80 in.-lb. torque per pound.



The new drives provide a particularly wide selection of ratios. They run virtually without noise in an oil-sealed cast iron housing, with a number of teeth carrying the load at all times so that there is a minimum of wear.

Black Tool says these units lend themselves to special applications and to integral design, especially where weight or space—or both—are important and where high torque is required. Sizes vary from small units for instruments to drives for large machine tools.

Circle No. 236 on Subscriber Service Card.

Small, Seamless Bellows Operate at 5000 psi

A new line of miniaturized, seamless, high-pressure bellows has been

introduced by the **Mechtronics Corporation.**

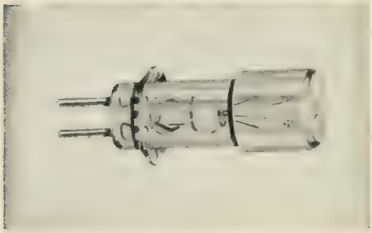
The bellows operate at pressures of 5000 psi or greater. Fifteen convolutions are precisely spaced over a one-half-inch active length and employ 100% of the functional wall area during operation. Deflection range is 45% in compression and up to 100% in extension. Effective area is 0.015 square inches on a 3/16" diameter.

Each bellows is gold-plated to provide maximum protection from extreme environmental conditions. The noble metal plating also provides an excellent surface for assembly by soldering or by epoxy-cementing techniques. Existing applications include high-pressure switches, valves and cryogenic systems for aircraft, missiles and space vehicles.

Circle No. 237 on Subscriber Service Card.

Clip-mounted Indicator Made for Instrument Use

Transistor Electronics Corp. has announced the production of a clip-mounted light indicator featuring single unit construction and press-on clip mounting.



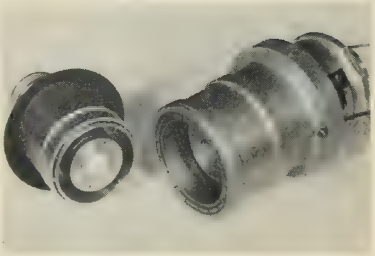
The CML mounts in a .294" hole and the circular clip permits mounting on ½" centers.

Available with a choice of neon or incandescent lamps, and with or without hot-stamped legends, the CML-series is intended for use in instruments and small equipment as well as on computers and data processors.

Circle No. 238 on Subscriber Service Card.

Quick Disconnect Couplings For Engine Start Systems

On Mark Couplings, Inc., has announced the availability of a two-inch Quick Disconnect Coupling for missile engine start systems. The coupling features pressure-balanced valving that will allow connection and disconnection under full 300° psi line pressure with zero spillage and air inclusion.



A high degree of reliability is achieved by rugged construction and simplicity in design of both the airborne and socket half. Full 360° gripping action is used for positive locking by means of a series of jaws that grip the mating half in the nature of a collet.

Circle No. 239 on Subscriber Service Card.

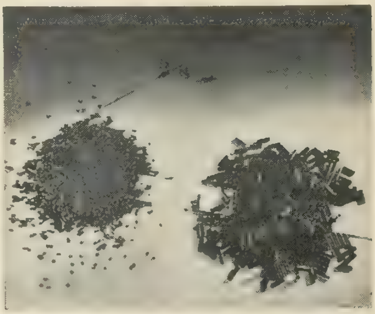
Anti-light Black Glass Has Semiconductor Uses

A black glass that is impervious to light has been developed by **Corning Glass Works** for enclosure of silicon semiconductor devices.

The glass is being offered in the form of beads and cases for sealing to standard .017 Dumet lead wires. The glass filters out virtually all wavelengths of the ultraviolet, visible and near-infrared spectrum to which silicon semiconductor crystals are sensitive.

The black glass eliminates the need to paint the devices in mass production and solves the costly problem of surface rub-off or scratching.

The company said the glass, designated Code 9361, has physical properties equivalent to the standard clear glass now used by diode manufacturers.



The new glass has resistivity similar to the bulb glass used in standard radio tubes.

Code 9361 glass has thermal coefficient of expansion of 92 x 10^{-7}/°C. Softening point is about 675°C; annealing point approximately 495°C, and strain point about 455°C.

The beads and cases are precision-made to tight tolerances. Bead O.D. is .053 (±.002) and I.D. is .023 (±.002). Case O.D. is .095 (±.002) and I.D. is .060 (±.002).

Circle No. 240 on Subscriber Service Card.

New Unit Provides Portable Refrigeration

Remote supplies can be packaged and transported at low temperatures to −120°F by a new line of refrigeration equipment produced by **Tenney Engineering, Inc.**

The Kold-Pak is a one-piece, packaged, mechanical refrigeration assembly that provides low temperature mediums to any enclosure through heat exchangers connected to the required flow lines. The exchanges are either of the direct expansion type, with freon refrigerants passing through a user's heat exchanger, or the brine chiller type with a liquid acting as a secondary cooling agent.

At −40°F brine temperature or −60°F evaporator temperature, the K standard models have a capacity from 3240 to 34,000 BTU/hr; at −100°F brine temperature or −120°F evaporator temperature, capacity ranges from 660 to 7000 BTU/hr.

Caster mounted for mobility, this source of low temperature makes it possible to refrigerate an independently built work space or to augment the capacity of other refrigeration equipment. The equipment is used as a source for rapid temperature changes in testing and in production for adaption to low-temperature baths, cold traps (vacuum equipment), quenching baths and metal treatment.

In atomic energy areas, refrigeration can be provided in a "hot" zone without endangering personnel. Expendable liquid cooling agents can be disposed of as they become contaminated.

Circle No. 241 on Subscriber Service Card.

Viscous-coupled Dampers Available in Two Models

A viscous-coupled damper designed for use in applications requiring high velocity and high torque constants has been produced by **Feedback Contracts Inc.**

The manufacturer claims that the low-cost damper replaces higher priced tachometers, networks, and other servo-stabilizers and that its performance is not affected by line frequency shift.

The compact unit consists of a flywheel, free to rotate inside a low-inertia shell rigidly fastened to the

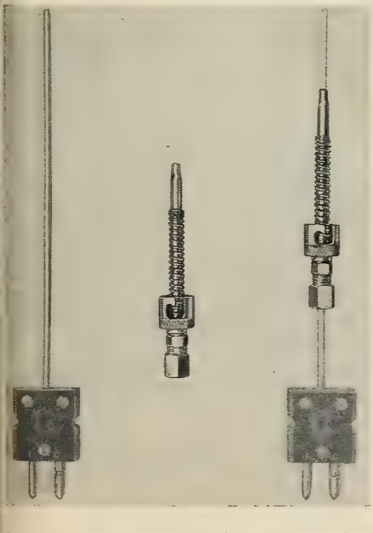
servomotor shaft. The damping action is produced by a special, viscous fluid between the flywheel and shell.

The viscous-coupled inertia damper is available in two models with a diameter of 1.52 or 1.79", and with 10 time constants ranging from 0.02 to 1.20 seconds. Damping action is factory-set for the life of the unit.

Circle No. 242 on Subscriber Service Card.

Adapter Adjusts Immersion Length of Thermocouples

Thermo Electric Co., Inc. has developed a thermocouple adapter which converts a 1/8" or 1/16" "Ceramo" (or other metal-sheathed tubular type thermocouple) to a spring-loaded thermocouple with an adjustable immersion length. This adapter solves problems caused by measuring temperatures at varying immersion depths in a system where a fixed immersion thermocouple would be impractical.



The adapter allows the user to adjust the thermocouple to any desired immersion length from a 1" minimum. It is constructed of a stainless steel sheath and cap, Inconel X or Stainless Steel spring, a nickel-plated brass compression fitting and a brass or nylon ferrule. The brass ferrule provides a permanent immersion setting while the nylon ferrule allows for adjustment of the immersion length.

The spring-loaded thermocouple compensates for expansion, contraction, and vibration by keeping the measuring junction of the thermocouple in intimate contact with the surface being measured. It can be used for measuring temperatures in engine or pump cylinder heads, turbine housing, pipes, electric motors, generators, transformers, plastic extruders, and other situations requiring an imbedded, spring-loaded thermocouple.

Circle No. 243 on Subscriber Service Card.

Titanium-base Alloy Strengthened by Heat

An alpha-beta type titanium-base alloy that can be strengthened by heat treatment is reported by **Crucible Steel Co.** The alloy, entitled Crucible O-135-AMo contains 7% aluminum and 4% molybdenum.

After heat treatment, a 1" maximum section has ultimate strength of 170,000 psi, 0.2% offset yield strength of 160,000 psi, 8% elongation and 20% reduction of area. In section sizes btween 1" and 2", ultimate is 160,000, 0.2% yield is 150,000. From 2" to 4", ultimate is 150,000 and 0.2% yield is 140,000.

Other properties: 0.162 lb./cu. in. density; 16.2 x 10^6 psi modulus of elasticity at 80°F; 3.70 BTU/hr/ft.^{2}/ft./°F at 68°F thermal conductivity.

Circle No. 244 on Subscriber Service Card.

New Gyro Wheel Supply Has Improved Regulation

A gyro wheel supply of improved regulation is announced by **Harrel, Inc.** Designated the WS213, the new unit is designed to drive three phase gyros from a single phase line.

Instead of the purely passive elements of a conventional phase splitter, the new unit contains a transistorized amplifier which provides a low impedance output and maintains good line-to-line voltage regulation.

The improved regulation can mean significant improvements in the drift stability of a high-precision gyro. Gyro motors differ greatly in impedance, even among units of the same lot of the same manufacturer, depending upon lubrication, wear, bearing preload, and many other factors. A low-impedance wheel supply maintains thermal symmetry in the gyro and reduces drift and uncertainty torques to a minimum.

The WS213 is completely transistorized for maximum reliability and draws all of its power from the ac line. One, two, or three gyros can be excited from the same wheel supply unit. The supply is furnished in a hermetically sealed enclosure and meets applicable MIL specifications for vibration and shock.

Circle No. 245 on Subscriber Service Card.

New Literature

POTENTIOMETER. A certified test report for engineers with trimming potentiometer applications is now available from the Helipot Division of **Beckman Instruments, Inc.** The report's 16 pages statistically describe the series 50 Helitrim trimming potentiometer, a ceramic/metal unit produced in quantity by Helipot. Fifty-one of these small cermet pots were subjected to various tests, and the results reported in detail. A complete summary of the pot's environmental capabilities is included, as well as a listing of test procedures and equipment used.

Circle No. 200 on Subscriber Service Card.

MAGNETIC CLUTCHES. PIC Design Corporation, a subsidiary of **Benrus Watch Co., Inc.,** is offering an 18-page, 8½" x 11" technical booklet entitled, "Magnetic Clutches and Their Applications." The booklet has complete details on design and applications, technical and testing specifications.

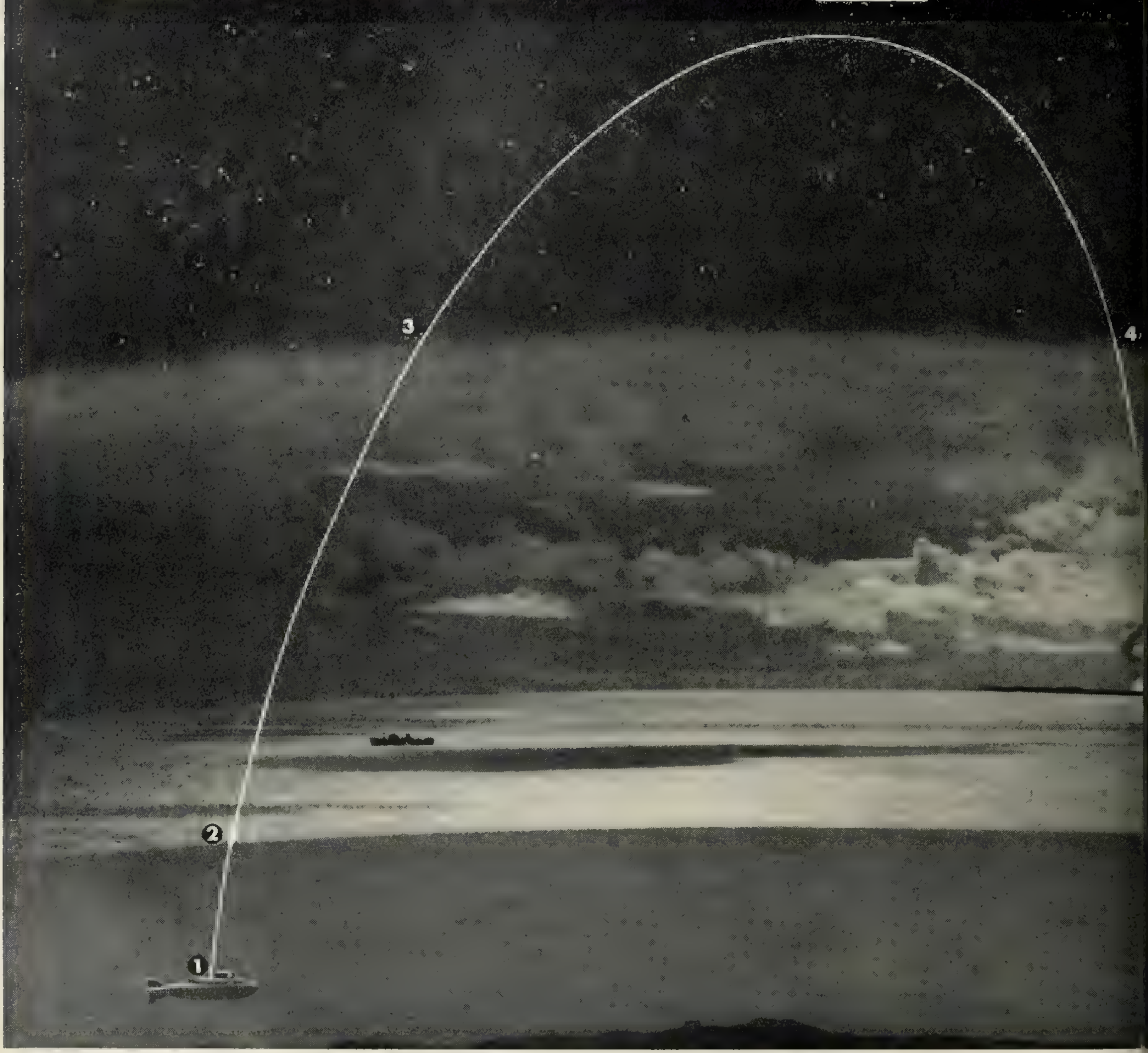
Circle No. 201 on Subscriber Service Card.

CONNECTORS. A 16-page condensed catalog featuring standard lines of electronic connectors manufactured by H. H. Buggie Division, **Burndy Corporation,** is now available. The catalog includes basic engineering application data on electronic connector types including printed circuit, MS, rack and panel, triaxial, glass seal, BT type (miniature) plugs and receptacles and cable assemblies. In addition, one page features special type connectors that have been engineered and manufactured for specific applications.

Circle No. 202 on Subscriber Service Card.

The U.S. Navy POLARIS, developed by Lockheed:

From ocean depths to *any* targe



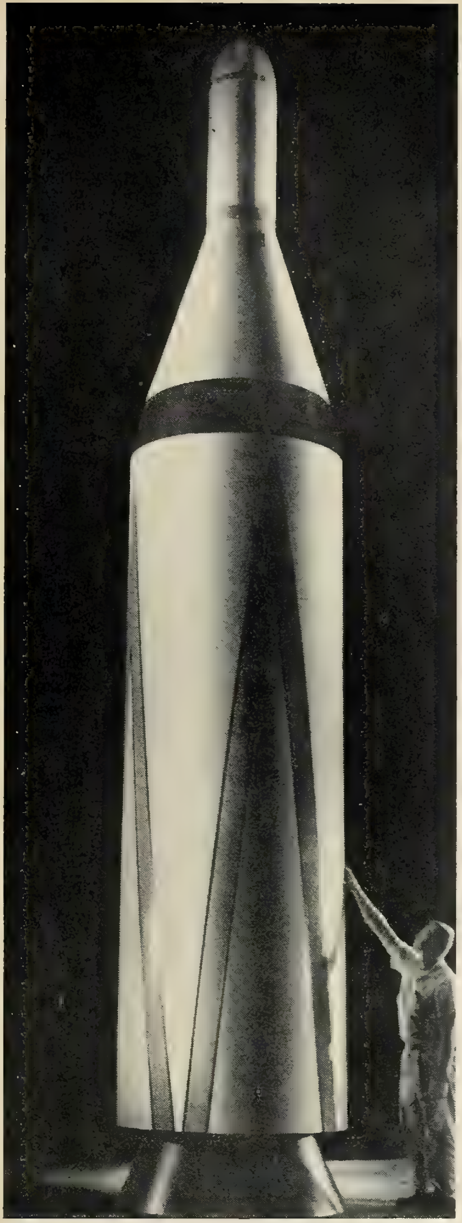
Navy's hidden nuclear submarine (1) launches a solid-propellant Polaris missile, which erupts from the depths (2), rockets its way i space (3). Plunging earthward minutes later, the warhead of the Polaris re-enters earth's atmosphere (4) and destroys its target (

America can breathe easier next year when the Lockheed-developed Polaris missile goes to sea aboard the Navy's nuclear-powered submarines—far ahead of original schedule. For every significant military target will be within its ultimate range of 1500 nautical miles.

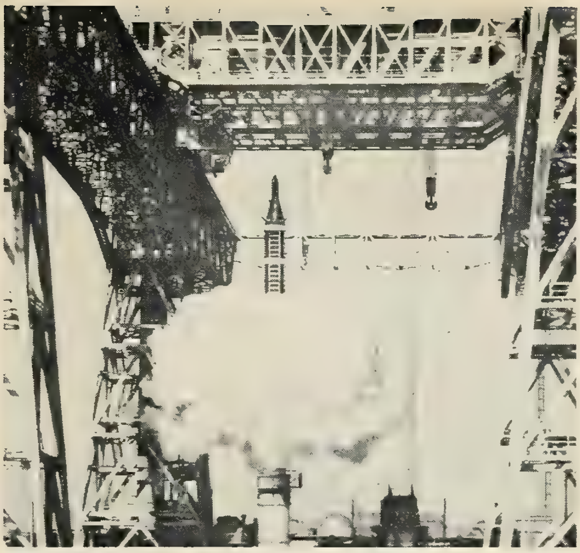
To be an effective deterrent to aggression, a weapon system must be safe from surprise, ready to strike back after any attack. The Navy's Polaris submarines will be immune to detection as they prowl submerged for weeks at a time. And they'll move the bulls-eye of enemy attack from our soil to the trackless depths of the sea.

Lockheed's Missiles and Space Division is Pola
Missile System manager and prime contractor — leader
an industrial team that includes Aerojet-General, Gene
Electric, Westinghouse, and hundreds of other contract
and suppliers, large and small. Close cooperation has brou
the Polaris from blueprint to hardware in record time.

This new combination of nuclear submarine and Pola
missile will round out the nation's arsenal and give us t
flexibility we need for adequate defense.



POLARIS is much smaller than other U.S. ballistic missiles of the same range, thanks to new miniaturization techniques developed by Lockheed scientists. This permits each nuclear submarine to carry 16 missiles.



"Operation Sky-Catch" is apt name for this huge overhead assembly. It catches POLARIS test vehicles in mid-air after test launchings. This prevents damage to components and gives more accurate instrument readings, thus saving time and speeding development. Tests are conducted jointly by U. S. Navy, Westinghouse, and Lockheed.

4,000-acre test base in the Santa Cruz Mountains of California is where Lockheed's Missiles and Space Division puts completed POLARIS missiles through simulated flights that prove the propulsion and guidance systems before actual flights of development missiles.

LOCKHEED

JET TRANSPORTS • JET FIGHTERS • JET TRAINERS • COMMERCIAL & MILITARY PROP-JET TRANSPORTS • ROCKETRY
BALLISTIC MISSILE RESEARCH & DEVELOPMENT • WEAPON SYSTEM MANAGEMENT • ANTI-SUBMARINE PATROL AIRCRAFT
NUCLEAR-POWERED FLIGHT • ADVANCED ELECTRONICS • AIRBORNE EARLY-WARNING AIRCRAFT • AIRPORT MANAGEMENT
NUCLEAR REACTOR DESIGN & DEVELOPMENT • GROUND SUPPORT EQUIPMENT • WORLD-WIDE AIRCRAFT MAINTENANCE

FIRST INTO OUTER SPACE, Theodore J. Gordon and Julian Scheer. St. Martin's Press, 197 pp. $3.95.

The book is a first person account of events leading up to the firing of missile 130, the first vehicle to penetrate outer space. Gordon, 29, is a Douglas engineer, test conductor of three Air Force probes described in the book.

RECOVERABLE BOOSTERS-THE NEXT BIG STEP IN SATELLITE AND SPACE SYSTEMS, R. P. Buschmann, Lockheed Aircraft Corp., Palo Alto, California. Order ARS-1012-59 from American Rocket Society, 500 5th Ave. New York 18, N.Y.

As a result of this study, a recommendation can be made for the practical application of recovery concepts. In the immediate future, the first stage of existing vehicles can be recovered by means of parachutes or a combination of parachute and retrorocket (pararockets).

Recovery of existing vehicles with high burn-out velocities is impractical. By 1963, the first and upper stages should be recoverable if steps are taken now to incorporate recovery features. In 1965, consideration can be given to the recovery of all stages, including stages in near-earth orbits.

A concept of a 1965 vehicle is shown. This is a three-stage booster of the *Nova* class whose first stage has wings. Turbojet engines will probably be used to return this booster. The second stage is a winged glider which is air-snatched and towed back to base. The third stage is parachute recovered by the air-snatch method.

DEVELOPMENT OF THE CAPSULE PRESSURE VESSEL FOR PROJECT MERCURY, Fred Sanders, McDonnell Aircraft Corporation, St. Louis, Missouri. Order ARS 987-59 from American Rocket Society, 500 5th Ave., New York 18, N.Y.

The need for early development and high reliability has led to use of materials previously developed for the Project *Mercury* capsule. In order to meet the severe environmental requirements and to keep the weight to a minimum, the full spectrum of these available materials is utilized and carefully integrated into the capsule pressure vessel.

The development of the capsule is traced from its overall purpose as related to the mission, through detail environmental requirements, materials and construction, to manufacturing processes and problems. A brief review of manufacturing processes and problems is then given. The environment association with each phase of the mission is outlined, which briefly illustrates the structural design criteria used.

TARGET FOR TOMORROW, Dr. I. M. Levitt; Fleet Publishing Corp., N.Y. $4.95

An easy-to-read description of some of the problems and objectives of space travel. Dr. Levitt, director of Fels Planetarium and a longtime author of books and newspaper columns on space, is that extreme rarity—a scientist who can discuss an exceedingly technical subject in accurate but simple terms.

The author briefly and explicitly describes the basic principles of our earth and planetary systems, travel to and life on other planets, and the practical problems relating to this new dimension. Although some may appear at first glance somewhat "blue-sky," Dr. Levitt's prognostications are based on solid scientific fact and scientist and layman alike will be impressed with the logic of his extensions.

ELECTROMAGNETIC RADIATION FROM CYLINDRICAL STRUCTURES, James R. Wait, Permagon Press, N.Y., Library of Congress Card 59-8284.

Presents a comprehensive review of the basic work in the field and theoretical treatment of slot antennas on cylindrical surfaces. Particularly of interest to missile structure and communications system designers due to the necessity of flush antennas in high-speed missiles.

ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING, Dr. Robert I. Sarbacher, Prentice-Hall, Englewood Cliffs, N.J., $35.00. Library of Congress Card 59-11990.

This massive reference work—the first complete compilation of information on these two specialties published in a single volume—is the result of 12 years' work. The 14,000 entries and 1400 illustrations cover all the modern terms and definitions relating to electronics and nuclear engineering.

MODERN ELECTRONIC COMPONENTS, G. W. A. Dummer, Philosophical Library, N.Y., $15.00.

A comprehensive survey of the characteristics of common electronic components, together with data on their operation in extreme environments. Includes component specifications, transistor-circuit components, reliability, and future developments.

THE CONTACT MODULATOR, Airpax Electronics Inc. Engineering staff, Cambridge Division, Cambridge, Md.

A six-pamphlet series on choppers has been compiled. The various parts are entitled, "Why Use Choppers?", "Definitions and Measurements," "Modulation Methods," "Applications and Performance," "Noise in Chopper Circuits" and "Chopper Amplifier Design."

Part 1 discusses why choppers are necessary and the types employed in the various applications. A glossary of chopper terms and mounting dimensions is included. In Part 2, detailed definitions and measurement of chopper parameters are provided and the test equipment used in measurement is discussed.

Part 3 is devoted to modulation methods and practical modulator circuits. Input circuits, phase relationship and the ambient changes are discussed in part 4.

The final two sections deal with noise sources, reduction of noise and comparative measurements, details of chopper amplifier design and frequency response in chopper amplifiers circuitry.

FOUNDATION OF AERODYNAMICS, A. M. Duethe and J. D. Schetzer, University of Michigan. John Wiley and Sons, Inc. 435 pp.

Presented are the foundations of aerodynamics. An effort has been made to treat the successive steps in the consideration of problems in viscous compressible fluids, to explain the concepts involved, and to show the extent to which the various approximation methods are valid.

Partial contents include; Kinematics of a Fluid Field, Introduction to Compressible Fluids, Some Applications of One-Dimensional Compressible Flow, and Turbulent Flow in Tubes and Boundary Layers.

MODERN NETWORK ANALYSIS, Fazlollah M. Reza and Samuel Seely, McGraw-Hill Electrical and Electronic Engineering Series. 368 pp. $10.

Written as an intermediate level text, the book gives its subject a modern treatment expressed in terms of the complex variable *s*.

Considerable attention is devoted to the response of networks to singularity functions, as well as to the more usual excitation functions.

The book concludes with a thorough discussion of general network properties—the positive real character of the driving-point network function, network stability, natural modes, and the specific properties of networks containing elements of only two types.

DAYTIME DETECTION OF CELESTIAL BODIES USING THE INTENSIFIER IMAGE ORTHICON. R. K. H. Gebel, WADC. Order PB 151866 from OTS, U.S. Department of Commerce, Washington 25, D.C. 45 pp. $1.25.

The daytime photographic techniques described may make it possible to probe farther into the universe than was previously considered possible.

An image orthicon, with and without intensifier stages, was combined with the Air Force's "Cat Eye" light amplifier installation. Daytime photographs of astronomical objects, including a full-face photograph of the moon, were produced in better detail than possible with conventional photography.

The report discusses the fundamental limit of sensitivity set by quantum statistics, the limiting star brightness detectable by the intensifier image orthicon, and the results of using this type of camera tube for daytime astronomical photography.

NAVY RELIABILITY DESIGN HANDBOOK and supplements. Order PB 121839, handbook and PB 1211839-S1 to 121839-S6, supplements from OTS, U.S. Dept of Commerce, Washington 25, D.C. Handbook $3, supplements $2.25 a year for subscription, or $.75 per copy.

The handbook is intended as a source of information on ways of achieving greater simplicity, economy, and reliability in electronics equipment for the Navy.

It presents new information on materials, processes, and techniques as well as design aids.

MAGNETISM AND ELECTROMAGNETISM, Edited by A. Schure. John F. Rider Publisher, Inc. New York. 78 pp. $1.80.

The book, volume 20 in the Electronic Technology Series, deals with those aspects of magnetism and electromagnetism which underlie the operation of communication and industrial electronic devices.

The intent is to give attention to the major theoretical considerations of magnetism, magnetic circuits, and electromagnetism at the intermediate level. The mathematical techniques used are simple but extensive enough to develop in the interested reader the mastery of typical computations.

APPLICATION NOTES FOR MILITARY RECEIVING TUBES, ARINC Research Corp. 1700 "K" St. Nw. Washington 6, D.C. 222 pp. $2.50.

This is a supplement to Military Handbook No. 211, Techniques for Application of Electron Tubes in Military Equipment, published by the Government Printing Office.

The handbook covers all data pertaining to the receiving tube types designated for use in military electronic equipment.

The supplement goes beyond the handbook in dealing with various application problems which are commonly encountered in complex equipments.

Part I discusses the design of circuits. Part II provides application data similar to that provided in the handbook.

SUBTERRANEAN LOGISTICS FOR ROCKET AND GUIDED MISSILE BASES, translated from Fusees et Recherche Aeronautique (France). Order 59-14110 from Photoduplication Service, Publication Board Project, Library of Congress, Washington 25, D.C. Microfilm, $2.70; Photocopy, $4.80.

The use of subterranean facilities is highly economical, in contrast to brick or cement buildings which are subject to more or less expansion and wear, in above-ground installations.

When dug several hundred meters into solid rock, a subterranean installation offers complete protection from Atomic weapons and will last for centuries.

COSMIC TELEVISION, Druzhkin, Translated from Sovetskiy Flot (USSR). Order 59-16340 from Photoduplication Service, Publication Board Project, Library of Congress, Washington 25, D.C. Microfilm, $1.80; Photocopy, $1.80.

Answers are summarized which were given L. A. Druzhkin to questions put to him by a correspondent of Sovetskiy Flot. Questions include:

1. Is it possible to use the satellites for TV purposes and if yes what advantages may be expected from that method? 2. How do you intend to realize transmissions from the satellites? 3. How long would the TV equipment of the satellite be able to operate normally?

THE CHARACTERISTICS OF HYDROGEN AND WATER AS WORKING GASES FOR REACTOR-HEATED ROCKET MOTORS, Irene Sanger-Bredt. Translation of Astronautica Acta (Austria). Order 59-21108 from Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. 51 pp. $1.50.

Hydrogen and water vapor have been investigated as to their applicability as working fluids with an energy higher by several orders of magnitude than has hitherto been available with steam boilers.

Enthalpyentropy diagrams are computed for either gas, with complete regard to dissociation, as well as ionization, over the pressure range between 10+1 to 10–5 atm, and within the temperature range between 500 and 10,000°K.

Three methods of heating the working fluid are investigated: fission reactor, arc, and fusion reactors.

DICTIONARY OF ATOMIC TERMINOLOGY, Lore Lettenmeyer, Philosophical Library Inc. 15 E. 40th St. New York, N.Y. 298 pp. $6.

The dictionary provides German, French and Italian translations of scientific terms employed in connection with atomic and nuclear physics, reactor engineering, radiation physics and associated fields.

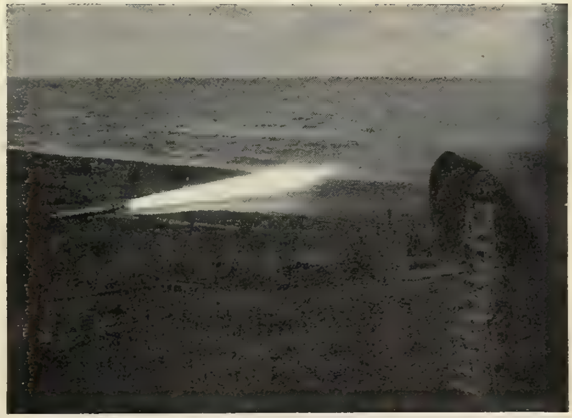
DYNAMIC ANALYSIS OF A SIMPLE REENTRY MANEUVER FOR A LIFTING SATELLITE, Frederick C. Grant. Order NASA TN D-47, from NASA, Technical Information Div. Code BID, Washington 25, D.C. 35 pp. $1.

Calculated angles, times, distances, and accelerations associated with a simple one-skip maneuver to a glide trajectory are presented.

The principal parameters considered are entry angle up to 6° and lift-drag ratio from ½ to 5. For the range of parameters considered, the limitations on the maneuver are indicated.

Newest Japanese Rocket Tested at Akita

K-420 IS LARGEST solid motor in Kappa project, studied at the University of Tokyo. Its diameter is 420 mm, length is six meters. Thrust is 10 tons, and duration is 15 sec.



THE ROCKET was tested on September 30, at Akita rocket test range. The K-420 will be used for *Kappa Type 7*, and for the booster of *Kappa Type 8*.

ASTRELLO

Paul H. Astrello, *Sidewinder* manufacturing manager for General Electric's Light Military Electronics Dept., has been named senior technical consultant to the U.S. Liaison Office, North Atlantic Treaty Organization *Sidewinder* program. Working under contract with the Navy, Astrello will advise NATO nations on techniques for manufacturing the air-to-air missile.

Astrello, who joined GE in 1942, has been in charge of manufacturing for the LMED *Sidewinder* guidance and control project since 1956. **Vincent A. Melfi,** formerly superintendent of *Sidewinder* Quality Control, will replace Astrello in this capacity, and **Robert H. Gripp** will replace Melfi.

ALESSI

Vincent Alessi has been appointed general manager of Dallons Semiconductors, a division of Dallons Laboratories, Inc.

Alessi's broad background and experience in the semiconductor field includes such key production executive positions as manufacturing manager at Texas Instruments, International Rectifier and the Hughes Semiconductor Division. In addition, he had engineering responsibility at Raytheon in the development of sub-miniature vacuum tubes and germanium point contact diodes.

Wesley L. Hjornevik has been named deputy director of business administration for the National Aeronautics and Space Administration.

Hjornevik has served as assistant to NASA Administrator T. Keith Glennan since the agency was formed. Prior to that he was assistant to the Under Secretary of the Department of Health, Education and Welfare.

MOORE

Beal P. Moore has joined Stavid Engineering, Inc. as engineering consultant assigned to the Airborne Electronics Department. He was formerly senior engineer and consultant to the advanced design staff at Aerojet General Corp. Moore attended the University of Texas and completed advanced courses in engineering and nuclear physics at Rutgers University and Stevens Institute of Technology.

MONTGOMERY

Edward L. Montgomery has been appointed executive assistant to the vice president and general manager of Aeronutronic, a division of Ford Motor Co. In his new assignment, he will be responsible for investigating programs to supplement the division's current product interests and new product areas to increase diversification and capability.

Montgomery joined Ford Motor Co. in 1950.

ATTEBERY

Arthur H. Attebery has been named chief of engineering services at Ryan Electronics, reporting to **C. H. Gottwald,** chief engineer.

Attebery comes to Ryan from Convair, where he spent six years doing "value," electronic parts and reliability engineering. Value engineering is a relatively new field, in which equipment is analyzed part-by-part for possible cost reduction on the basis of function. Earlier, Attebery spent seven years at Naval Electronics Laboratory and four years at the Air Force's Wright Field.

TISHLER

Sperry Semiconductor has appointed **Carl Tishler** applications engineer responsible for evaluation and application of advanced semiconductor products for this division of Sperry Rand Corp. Tishler has had several years' experience in semiconductor applications with the Remington Rand Division, where he worked on transistorizing computing equipment, including high-speed printers. He was also responsible for developments in the area of high-current transistor driving circuits for computer memories.

Prior to joining Remington Rand, Tishler had been a circuit design engineer with Barnes Engineering, MB Manufacturing and General Electric.

William C. Benson has been promoted to manager of ground support equipment sales at Solar Aircraft Co. He will handle sales activities directed toward three major fields—ground power for missiles and aircraft, development of transportation and handling equipment and electrical checkout support equipment programs.

Benson came to Solar as a project engineer from Beech Aircraft Corp., where he was manager of support equipment. Prior to joining Beech he was chief engineer for Spencer Safford Loadcraft, Inc., and before that, chief engineer for American Body and Trailer Co.

Victor J. Grubenhoff has been appointed assistant manager of industrial engineering for Jack & Heintz, Inc., developers and manufacturers of power systems for aircraft, missiles and support equipment. In his new post he will assist in the supervision of the company's methods engineering section.

Grubenhoff was formerly supervisor of industrial methods engineering for Westinghouse.

James B. Williams has been elected vice president-engineering of Electronic Communications, Inc.

Williams was previously director of weapons-system engineering for Philco Corp., where for a number of years he acted as executive and later chief engineer of weapons-system engineering.

Dr. Charles E. Reed has been named general manager of the Chemical and Metallurgical Div. of General Electric Co., succeeding vice president **Robert L. Gibson,** who has been appointed general manager of the company's Transformer Division.

Dr. Reed was formerly general manager of the company's Metallurgical Products Dept. in Detroit.

A. G. Puglisi has been chosen chief engineer of the Douglas Aircraft Co.'s Tulsa Division.

E. S. Rutowski, former chief of the Tulsa aerodynamics section, will succeed Puglisi as assistant chief.

Rudolph A. Rieder has been appointed operations manager for United Aircraft Corp.'s Norden Division Data Systems department. He will be responsible for all manufacturing, material control, facility maintenance and industrial engineering.

Prior to joining Norden, Rieder was with Librascope Inc. for six years, serving as chief production engineer.

Joseph E. Trankla has been named to the new post of assistant general manager at Anadite, Inc. Trankla, credited with developing many of the new skills and techniques for hard anodizing of aluminum, was for the last four years director of research and development for the Anachrome Corp., an affiliate company of Anadite, Inc.

Dr. James H. Fisher has been elected to head a newly formed advanced technical planning group at Electro-Optical

Systems, Inc. Dr. Fisher will also continue as manager of the company's energy research and advanced power systems division, a position he has held for the past two years.

Kearfott Company, Inc., has appointed **Ronald Paradise** head of its Electronics Laboratory. He joined Kearfott in 1954 as an assistant project engineer.

Hughes Aircraft Corp. has appointed three executives to managerial positions: **David A. Hill,** formerly manager of the Santa Barbara Research center, to manager of the semiconductor division; **Lloyd H. Scott,** former director of engineering change management, to manager of the Santa Barbara Research Center, and **L. James Levisee,** previously semiconductor division manager, to director of material.

Norman P. Johnson has been elected assistant chief industrial engineer for Norton Co. He joined the firm in 1951 as a time study engineer.

A. N. Ballard has been named factory manager of Summers Gyroscope company and **Fred Heine** has been appointed head of The Potter Instrument Co.'s product engineering department.

Device Permits Visual Check of Grain Surfaces

AZUSA, CALIF.—Visual inspection of the internal surfaces of solid-rocket grains is possible with the BoreSCOPE, a development of **Aerojet-General Nucleonics.**

The device allows the operator to view all points with the same power of magnification. The light source provides a constant level of illumination so that no attenuation occurs as the object distance increases.

The light is filtered and, along with the electrical components, is located at the ocular end of the instrument eliminating the introduction of dangerous elements into sensitive areas.

Magnezium-Thorium Alloys Are 30% of *Bomarc* Ramjets

MIDLAND, MICH.—Magnesium-thorium alloys developed by the **Dow Chemical Co.** constitute 30% of **Marquardt's** *Bomarc* ramjet engines.

Designated HM21A, the alloy castings are used in the control system for the fuel pump housing, air turbine inlet ducts, the Mach sensor and shock positioner housing and the fuel inlet.

Structural applications include the nose cone, longerons and diffuser inner body. The total weight of the alloy in the engine is 300 lbs.

letters

Economy First

To the Editor:

You view with alarm the present state of our missile progress and propose a crash program at costs far beyond present Administration plans even if such a program would unbalance our national budget . . .

Before we get hysterical over our lag in missiles, it would be well to consider two things: a sound American economy is more important than equality or leadership in missiles; and a much huskier missile program is possible, if we really want it, without upsetting our national budget.

One of the best things that has happened to our nation since the war has been our realization that we are behind Russia in rocketry. Otherwise we would have become insufferably cocky—like some missile industry ads (*sic*)—and completely obnoxious to the rest of the world . . .

Our missile program should be based on a realistic appraisal of our needs rather than on political popularity of a big-money crash program. Are the exceedingly expensive hardened underground bases for ICBM missiles necessary? It was an eye-opener for me to read that the *Nike-Zeus* program was planned not to protect our cities (which is hopeless), but to protect retaliatory ICBM bases. The entire system of ICBM bases with protecting *Nike-Zeus* looks too much like a modern Maginot Line.

Wouldn't unprotected, mobile ICBM bases combined with foreign IRBM bases and a *Polaris* Navy be a much better retaliatory force? Our Administration should decide these questions on their own merits without pressure from missile manufacturers or magazines . . .

If a larger military and space budget is required, it is possible to have this with a balanced budget if we want it enough to give up some other expensive frills. Mr. Kallis didn't suggest such an educational program, but let's have enough political nerve to ask for:

A rapid end to farm subsidies.

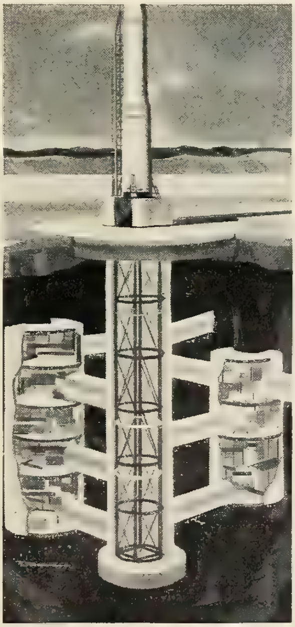
Retrenchment of stockpiling to actual security needs.

Continued high taxes until reduction is safely possible.

Revision of labor laws to give the large unions a right to bargain, but not to bludgeon.

Then let's have good, healthy progress in rockets, science, education and our national economy.

Edwin P. Plueddemann
Route 2
Midland, Mich.



1939
Ets-Hokin and Galvan installed "Mousetrap" rocket launchers on U.S. Navy sub-chasers.

1956
EHG pioneered in the installation of electronic systems of test and launching complexes for Intercontinental Ballistic Missiles.

1959
EHG has now installed or serviced the electrical and electronic phases on most of the ICBM complexes in the United States.

Installation Specialists to the Space Age

I INSTRUMENTATION WIRING
C COMPLETE INSTALLATION
B BASE COMMUNICATION SYSTEMS
M MISSILE GROUND SUPPORT SYSTEMS

EHG

ETS-HOKIN & GALVAN
551 Mission Street, San Francisco, California
Wilmington, San Diego, Stockton, Monterey, Oakland, Sacramento, Vandenberg AFB, San Mateo and Downey, California; Cape Canaveral, Florida; Denver, Colorado; Phoenix, Arizona; Cheyenne, Wyoming; Las Vegas, Nevada.

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letters

Points Well Taken

To the Editor:

Both Mr. George Beardshall and myself were most gratified by the very full coverage given to our recent paper concerning Cabin Conditioning Equipment for a Satellite (M/R, Oct. 5, p. 26).

We should like to point out one minor error of printing which is certain to have caused some confusion to those readers who studied the quoted weights in detail.

In Fig. 4, a diagram showing the component parts of the system, the decimal point of a number of the weights was omitted, causing in some cases an increase of weight either by 10 or 100 times.

Another point which may have confused your readers, and which is our fault, is the statement that the oxygen supply in its container represents the heaviest item of the system; in fact, of course, we were referring to the pressure control side and it will be realized that, using absorbents of known type, the chemical absorption equipment represents a very high proportion of the total system weight.

P. W. Fitt
Project Engineer (Oxygen)
Normalair, Limited
Yeovil, England

M/R regrets the omission of decimal points. Here are the correct weights (with incorrect figures in parenthesis): discharge valve, 1.0 lb. (10 lb.); isolating control, .25 lb. (25 lb.); inwards relief valve, .75 lb. (75 lb.); manual shut-off and n. r. v., .5 lb. (5 lb.); manual humidity control, .5 lb. (5 lb.); 2-way valve for circulation induced by breathing, .25 lb. (25 lb.); manual control for recompression, .25 lb. (25 lb.); liquid oxygen storage, total: 4.5 lb./man/day (45 lb.), and pressure controller, .75 lb. (75 lb.)—Ed.

Temperature Transducers

To the Editor:

In your Oct. 12 issue under the Astronautics section, you published a rather descriptive article on the various types of transducers being manufactured for the missile industry today. In addition to the three companies mentioned in your article, **ASTRA TECH** and other companies make temperature-measuring instruments.

Of interest was your discussion on page 36 of the temperature transducers. The reasons for using thermocouples or variable-resistance transducers seem to have been transposed in your description. Actually, for rapid response and accuracy (30 to 100 milleseconds and .1°F), the variable resistance-type transducer is most used by missile manufacturers.

Also, for a higher signal output and durability under high vibration and shock, tungsten elements are specified. By comparison, where requirements call for time constants ranging from 100 milliseconds to seconds, with accuracies of ± 2°F, thermocouples are most generally used. From this comparison, it can be seen that more resistance-type temperature transducers will be used in the future as requirements become more and more demanding for both the cryogenic and high-temperature fields.

Jack Probst
Sales Manager
ASTRA TECH
South Pasadena, Calif.

Small Firms' Headaches

To the Editor:

Thanks for your editorial of Oct. 26 ("A Captive Small Business?"). As a small business which has been a leader in handling the very difficult process of heat treating rocket and missile bodies, we agree in general with your conclusions. We shall be glad to write our Congressman if you will indicate the most appropriate time, presumably not now.

However, we suggest you pursue this subject further for the purpose of aiding the small business in some of its other problems, for example:

Secrecy. Under the guise of military secrecy of classified information from subcontractors. Our particular field is metallurgy. We know our business, having been engaged for more than 30 years in aircraft, rockets, and other essential Government work.

Rocket engineers, though brilliant and well versed in their field, are apparently behind the times in the application of basic metallurgical principles. Accordingly, they embody specifications in their designs which tend to retard rather than assist in the solution of difficult metallurgical problems, especially the reduction of weight and the achievement of close dimensional tolerances for best ballistic performance—but they are reluctant to discuss this.

Wasted time and effort. There has, during the past 2 years, been a flood of "inquiries" covering, for example, the heat treatment of rocket bodies of an endless number of designs. The contractor or subcontractor sends out inquiries and wants a reply "by telephone or return mail." This is quite burdensome as it takes several days to figure out the best and most economical proposal. Accordingly, a "horseback" figure must sometimes be given, to the mutual detriment of bidder and purchaser. In any event, a lot of effort is spent on figuring. After this frantic demand for immediate reply, months go by without any action whatever. In fact, one seldom hears further about the matter.

Subcontracts. As to placing subcontracts, it has been obvious that the "learning curve" is neglected. Contracts are placed with suppliers who have little or no experience in the field, who fail to understand the technical problems involved and who consequently put in a low bid—too low to permit satisfactory attention and performance without loss. Meanwhile, a competent bidder who has put in a fair price, based upon experience, loses the job. Then the buyer gets an unsatisfactory job from the inexperienced supplier or must waive technical requirements which should have been met.

Padding of payrolls? It is almost impossible for the small technical organization to hire a competent engineer today. Enormous ads appear in daily papers offering most tempting inducements to engineers. When one walks into the plants of one of these companies one sees "acres" of engineers apparently doodling. At any rate, the output is not commensurate with the size of the staff. Is this cornering of the market of engineers necessary? Is there a financial benefit to the contractor in having a large number of engineers, (relatively non-productive) on his payrolls?

There is plenty of opportunity for your excellent magazine to render a real service to the industry, including both large and small business, by a courageous campaign of investigation and truthful reporting.

A Reader

Obfuscous Syllabub?

To the Editor:

I was fascinated by your Nov. 23 issue. The information is timely and certainly summarizes the challenge facing the nation's materials engineers. I feel it unfortunate, however, that you let one article creep in written in something other than English. This particular article is so timely that I need to check a few translations with you for fear of drawing false conclusions—and maybe even killing myself.

1. Does "most refractory coatings to date exhibit lack of reliability when subjected to impingement of entrained particulate matter in the propellant stream under extended firing durations" mean

"The exhaust gas eventually chews hell out of existing ceramics"?

2. Does "Abortive missions induce greater hazard to terrestrial ecology and can completely inactivate firing stands and launch areas in case of catastrophic failure" mean

"Shooting off nuclear rockets is dangerous and, if they go boom on the ground, a lot of people are killed"?

Yours for better editorial controls,
Gordon S. Mustin
4710 W. Langley Lane
McLean, Va.

We are in substantial agreement with Mr. Mustin. It developed that the increment of editorial volume for the issue in question was of an order of magnitude such that even optimum utilization of the in-house capability of our desk failed to achieve total obviation of redundancy. Besides, it was a good article anyhow. Ed.

missile business . . .

By WILLIAM E. HOWARD

In its struggle to make the huge military supply system more manageable, the Defense Department now is ready to turn to industry for aid in setting up more realistic standards and eliminating duplication. This word comes from Perkins McGuire, assistant defense secretary for supply and logistics.

Wherever possible in the future, says McGuire . . .
"we intend to adopt industry specifications, standards and practices whenever they will meet our needs. We will not establish duplicating or overlapping military efforts. Furthermore, we will be seeking more industry participation in our future standards operations. In addition, under our weapons systems contracting program, we will be giving prime contractors more responsibility for insuring the use of standard parts and for developing proposed military specifications and standards required in the production and operation of the weapons."

One reason for this departure, McGuire says, is that a study by the American Standards Association revealed "a real question" whether there could be across-the-board standardization as originally envisioned by the program. "We now realize we must concentrate our efforts in vital high-payoff areas and must turn our back on many (low-payoff) desirable standardization projects which are not absolutely essential."

While not mentioning any specific areas of attack . . .
the assistant secretary made it clear that the main effort to obtain savings through uniformity of procurement will be directed at the big missile programs. The multimillion-dollar weapons systems, he said, "urgently" need standards and specifications.

The study also disclosed that not only were many military projects duplicating industrial projects, but DOD "had not been taking advantage of the wealth of technical competency in manufacturing industries and technical, trade and professional associations." McGuire said there is also a need for a more aggressive engineering standardization program at the drawing board, to avoid the need for standardization after the items are produced and in the supply system.

He said these various improvements are now being programmed into the DOD standardization effort and will be in effect before next July.

Big savings in dollars and engineering time . . .
are anticipated by McGuire in the DOD's new military standard and specification for engineering drawings—which replaces 158 different Army, Navy, Air Force and Marine Corps specs. The uniform drawing spec for all military services was developed by the Navy; it eliminates the need for a manufacturer under contract to more than one service to redraw his engineering documentation.

Cost of engineering documentation to DOD, incidentally, is estimated by McGuire at upwards of $2 billion a year.

All items in the military supply system now are catalogued uniformly. And this recently completed monumental task has revealed there are 3.5-million different items stocked by military. These items are manufactured and supplied by more than 34,000 companies. Some 500,000 new items come into the supply system every year and an equal number of obsolete or surplus items are eliminated.

McGuire said the single manager system for procuring commodities for all services appears to be working out well, opening up the possibility that it may be tried in some phases of missile procurement —perhaps for support items or missiles purchased by more than one service i.e. *Hawk* for the Army and Marine Corps.

Looking at DOD reorganization from the logistic . . .
point of view, McGuire says he can't see it as a panacea. "We're afraid we would only be reorganizing our problems—not solving them."

Lunik II Impact May Have Contaminated the Moon

BLOOMINGTON, IND.—The Russians may have contaminated the moon.

The final-stage carrier of *Lunik II* apparently was not decontaminated, although the instrument package was reportedly sterilized, according to Carl Sagan, of the Yerkes Observatory, University of Chicago.

Speaking to a meeting of the National Academy of Sciences at Indiana University here, Sagan said that if *Lunik II* was carrying terrestrial microorganisms when it hit the moon on Sept. 13, the resultant biological contamination could be an unparalleled scientific disaster in three ways:

- The moon may contain no indigenous living organisms, and may be incapable of supporting terrestrial microorganisms. But on or beneath the lunar surface there may be relics of organic matter or primitive organisms which arose during the moon's early history. There are other theories on lunar organic matter, and on the possible existence there of organisms of interplanetary origin.

The area contaminated by the impact of earth-launched vehicles would be rendered useless for establishing whether any of these notions is right or wrong.

- The moon may contain no indigenous living organisms but may be capable of supporting some earth-born organisms. Subsurface heat sources, water and organic matter would be required. Then there is the possibility that terrestrial organisms might form a biological explosion which would destroy prebiological organic matter surviving from ancient times.

- The moon may contain indigenous living organisms, and deposition of earth forms would upset balance and abundance of such organisms.

The survival of terrestrial microorganisms in space, and on the moon, depends on shielding from the sun's radiation. Sagan said lack of oxygen and extreme temperature is known to have little or no effect on some of the hardier organisms, but ultraviolet radiation will eventually destroy them.

He explained that the surface of the moon is a semiporous matrix of congealed dust particles. Terrestrial microorganisms lodged in the pores would be shielded from the solar radiation and would survive for long periods.

Speculation that there may be organic remains on the moon is based on the idea that the moon may once have had an atmosphere of methane, ammonia and water. Solar radiation is known to form organic molecules in such an environment.

moscow briefs

by M/R Staff from Translations

Red Scientists Criticized By Russian Academicians

Editor's note: N. A. Kozyrev has recently made news in both the East and West for his time-space hypothesis and his theories regarding lunar eruptions. These theories have come in for criticism by U.S. scientists and are now being attacked in the Soviet press by Russian scientists. This is indicative of a recent trend in the Soviet Union for scientists to wage war in the press against another's theories; it also reflects recent charges that claims by some Soviet scientists and journalists have been irresponsible and damaging to Russian prestige. The following are excerpts from an attack by Academicians L. Artsimovich, P. Kapitsa and I. Tamm on Kozyrev's theories in the Nov. 22 issue of Pravda:

". . . Cases are encountered when the popularization of many scientific and technical achievements is replaced by rushing after cheap sensations and the printed page is turned over to completely incompetent people . . . As an illustration let us consider the . . . 'revolution' in science presumably caused by N. A. Kozyrev, consisting particularly in discovering the possibility of 'using the course of time to obtain energy' . . . Kozyrev's book, "Causative Mechanics," (published) in 1958 . . . begins with the problem of sources of energy radiated by the stars.

"At present, science considers that the basic source of energy lies in the thermonuclear reactions occurring inside the stars. Not only without analyzing the facts but without a single word about nuclear energy, the author on the basis of unconvincing discussions taking up a number of pages asserts that 'inside the stars there are no special sources of energy.' This is what leads him later to the conclusion that the first and second laws of thermodynamics are incorrect, and in particular the physical law of the conservation of energy.

"Of course, the fact that the law of conservation of energy is strictly fulfilled in all processes occurring within the limits of our planet does not provide a basis for denying categorically the possibility that phenomena on a cosmic scale are subject to some different laws. In modern cosmology daring hypotheses of such types are much discussed. We are not against daring hypotheses, but favor them only when they are convincingly based. This is not the case in Kozyrev's book . . . The real meaning of his assertions that the course of time can create energy remains incomprehensible to us . . .

"The form of all the planets including the earth must, according to Kozyrev, be somewhat asymmetrical, pear-like, and their northern hemispheres must be more massive than (their) southern (hemispheres). Recent measurements of the earth's magnetic field have actually revealed a very slight asymmetry in the shape of the earth. However, the character of that asymmetry is directly opposite to the predictions of Kozyrev: the southern hemisphere is more massive than the northern . . . One needs not only a high degree of accuracy when setting up experiments but also thorough analysis proving that observable effects are not the result of secondary causes. Such an analysis is not given by Kozyrev . . .

"From the fact that Kozyrev's experiments are absolutely unconvincing and unsatisfactory from a methodical point of view we do not at all want to draw the conclusion that they should not be checked and analyzed. We consider it absolutely correct that thorough checking of this type has been taken up by the Pulkovo Observatory . . .

"Meanwhile, the well known writer Marietta Shaginyan in an article devoted to Kozyrev ("Time with a Capital." *Literaturnaya gazeta,* Nov. 3) says that she absolutely believes that theory . . . The only positive opinion of a physicist about Kozyrev's 'discovery' which Shaginyan was able to give contains the following reservation: 'I have not read Kozyrev's book and do not know his theory.' However, it is hardly necessary to analyze in detail her article. Its style and character would suit the assertion of a new faith better than the explanation of a scientific problem . . ."

Lunar Surface Analyzed

Scientists of the Main Astronomical Observatory in Leningrad and the Kharkov Astronomical Observatory recently rejected the theory held by many U.S. astronomers that the lunar surface is covered with dust particles, according to an article written by astronomers N. P. Barabashov and A. T. Chekirda in *Astronomicheskiy zhurnal* (Vol. 36, No. 2, 1959, pp. 315-321, and No. 5, pp. 851-855.)

The Soviet astronomers contend that the lunar surface is most probably covered with disrupted tuff-like rocks with scattered large-grain volcanic ash, and state that this conclusion was arrived at by parallel application of several different physical methods.

The various studies used, according to Barabashov and Chekirda, were: brightness for integral light; the reflection coefficients for different regions of the spectrum; the law of reflection of light; the smoothness factor; the energy distribution in the spectrum; curves giving the variation of the degree of polarization in dependence on the angles of incidence and reflection of light; and the phase angles, thermal conductivity, and density of the moon.

The characteristics of lunar objects also were compared to earth rocks whose surface had been irradiated by ultraviolet rays, X-rays, and protons in vacuum. The rocks had been fused at atmospheric pressure and in vacuum, and then broken up into grains of various size and striated before and after fusion. The combined results of photometric, calorimetric, and polarimetric investigation were utilized to compare results with tests of terrestrial rocks thought to be most similar to those on the moon.

The studies present the final concept of a lunar surface covered with a porous, sponge-like material, sharply striated and fragmented, and very probably with sharp spikes and deep furrows. This material may have originated from the solidification of lava foam (sytinskaya), and its composition may possibly be similar to that of the basic magnesium-bearing rocks, like gabbro and basalts. The paper states that Lambert's law and the deviation from it gave the criteria for distinguishing between the dusty martian and the clastic lunar surface.

The Soviet astronomers believe that the lunar surface was caused by explosions accompanying the impact of meteorites on its surface. This "meteor slag" theory, according to the article, is confirmed by the determination of such low values of the possible lunar atmospheric density that even micrometeorites can reach the lunar surface with cosmic velocities.

Telemetry Improvements

N. V. Pozin has written in *Avtomatica i telemekhanika* (No. 10, 1959, pp. 1403-1408) that a method of designing coders has been proposed that would take into account spectrum characteristics of the signals to be transmitted, and would use automatic control of transmission speed.

after rash of troubles . . .

Titan Is Re-evaluated by AF/STL

Program judged technically sound, but management is questioned; industry feels DOD must provide truth on all ICBM claims—or Congress may do the job

by William J. Coughlin

LOS ANGELES—The Air Force has just completed a full-scale re-evaluation of its controversial *Titan* missile program.

The technical portion of the study was made by **Space Technology Laboratories** on behalf of USAF's Ballistic Missile Division, MISSILES AND ROCKETS has learned.

Re-evaluation covered all aspects of e program, including a new study of the military requirement for *Titan,* design evaluation of the missile itself and a close scrutiny of **Martin Company** management of the program.

BMD is said to have concluded that there still is a military requirement for the *Titan* and that the missile is technically sound. Company management of the program has been questioned, however.

• **Series of troubles**—The resurvey was spurred by troubles which have plagued the Martin ICBM since last May. These reached a fiery climax Dec. 12, when the first of the *Titan C* series exploded on the Cape Canaveral launch pad. The accident is said to have been caused by a malfunction of the safety destruct system simultaneously with launching. All other systems were reportedly operating properly and the destruction system should not have been activated prior to lift-off.

It is understood that an electrical relay in the destruct system accidentally closed mechanically due either to vibration or a structural weakness.

The destruct system was recovered Dec. 14, and cause was pinned down to a relay in its lower part.

A previous *Titan B* launch attempt Aug. 14 also resulted in a burnout on the pad. That accident was blamed on the master operating control (MOC) system cutting off the rocket engine during lift-off after an umbilical line failed to release promptly. The missile fell back on the pad and burned.

• **Questions on the Hill**—The recent explosion of the 90-ft., two-stage missile could be politically damaging to the program in the light of congressional hearings on the defense budget slated for next month. A full-scale congressional probe of the *Titan* program early in the year is possible.

Present programming calls for 13 **Convair** *Atlas* squadrons, 14 *Titan* squadrons. *Atlas* backers assert something like $400 million could be saved by cancellation of the *Titan.*

One question which could be raised by Congress is whether need for *Titan* still exists.

The degree of *Atlas'* operational capability and the status of the **Boeing**

What Congress May Ask about ICBM's

WASHINGTON—When and if Congress, with its budget-pruning knife poised for slashing, attempts to clarify the muddled Air Force ICBM program, look for action in these principal areas:

TITAN

• A blow-by-blow account of test firings. Whether they met schedule, and if so—whose schedule? Exact cause of failures, whether technical or procedural errors. How much slippage in program, and why? Is fault technical or management? What effect will slippage have on operational dates? Back of it all will be the underlying questions: Why three Air Force ICBM systems? What are the merits of hardened sites vs. unhardened—and hardened vs. mobility? And—in light of touted capability of the other two systems—is the *Titan* road necessarily the correct road?

ATLAS

• What is its true operational capability now? Up for close scrutiny will be some claims that improvements —either made or contemplated—will give it range equal to *Titan's* and the same or improved guidance accuracy. Deciding factor—if it can match or achieve *Titan's* distance and accuracy—could be amount of payload it can carry. Latter, in turn, could affect *Minuteman* program with its smaller nuclear warhead. Look for Congress to attempt to place blame in individual areas for lack of true public information on claims and counterclaims which have been promulgated by all factions in the ICBM program.

MINUTEMAN

• How much bang will we get for the buck? How is the program proceeding technically? Look for another round of claims and counterclaims on merits of liquid systems vs. solids. Barbs which may be aimed at *Minuteman:* Difficulty in transporting big solid motors, high cost of mobility, whether "instantaneous readiness" is really necessary and worth the cost of hundreds of hardened silos.

POSSIBLE CONGRESSIONAL OUTCOME: Either more mud in the ICBM water or decided recommendations on what program or programs should be pushed—with funding determining the degree.

tightening called for . . .

Minuteman program undoubtedly will have a direct bearing.

But the Air Force study indicates that in the critical time period ahead—the so-called "Missile Gap" in 1960-65 when the United States will lag behind the Russians—both *Titan* and *Atlas* will be necessary to provide the maximum number of operational missiles.

BMD's study finds that stepping up *Atlas* production at Convair's San Diego facility—or phasing in of a second *Atlas* production line—would not provide as many missiles in the critical period ahead as continuing with both programs.

This statement has been challenged by those who believe that *Atlas* production, with adequate funding, could be increased to meet the gap.

- **How much slippage?**—Past, and any future, trouble with *Titan* could make the program one of the most controversial in the defense budget. Defenders of *Titan* point out that the *Atlas* also was plagued with a long series of disasters in the early stages of its program, including five straight launch failures.

Titan originated as a backup missile to the *Atlas*. Its two-stage conventional-airframe approach was considered insurance against difficulties which might arise with the pressurized thin hull and so-called "stage-and-a-half" design of *Atlas*.

Contract for the *Atlas* was let in March, 1954. The *Titan* contract came in October, 1955.

The Air Force acknowledged in December, 1958, before the first *Titan* launch, that the program had slipped slightly while that of the *Atlas* was being accelerated. This spread the operational dates for the two missiles to approximately 18 months apart.

Titan proponents, however, insist that a more realistic figure would be 12 months.

At the moment, with a very few *Atlas* missiles now operational at Strategic Air Command's Vandenberg, Calif., base, some sources say *Titan* has fallen roughly another six months behind and that there have been something like seven launch schedule revisions since the first of the year. *Titan* proponents, however, question the use of "operational," and insist that it should be clarified to "technically operational."

They add that the operational *Atlas E* has yet to be fired, and *Titan* will reach *Atlas'* present capability in October, 1960. The additional program slippage of six months also is questioned, but no revised estimate of slippage is given.

The Air Force believes, however, that *Titan* can become operational on its present schedule, sometime in 1961. This will require a tightly-run program to make up the present lag. Close USAF supervision will be maintained over Martin Company management of the project to assure that this comes about.

- **Basically sound**—Even strongest opponents of *Titan* will admit that the missile appears technically sound, despite its chain of mishaps.

Firing of the series of four *Titan-A* missiles, designed to check out engine-frame compatibility and first-stage control, went off well. *Titan's* last successful launch was on May 4.

Since then, one disaster after another has wiped out or damaged practically the entire series of *Titan-B* missiles. A tank was badly damaged while being cleaned at Martin's Denver plant. First stage of another was damaged during air shipment to Cape Canaveral, as a result of uncorrected pressure differential. First stage of one was extensively damaged on the pad at Canaveral when a helium line tore loose. Two engines exploded in "battleship" firings at Denver.

Not all of the B missiles—about nine—can be accounted for because some apparently have been cannibalized. Last of the B series was on the Canaveral stand in November, and is next in line to be fired.

Firing of this "bird" could come at any time. However, it would take at least six weeks for a firing from a C stand.

There are three stands at the Cape and one under construction. The first of the existing stands was used for A and is now modified for G and C. The second is for B, and the third is for C. The latter was damaged on Dec. 12.

Series B was to be used to test altitude start of the 80,000-lb.-thrust second-stage engine as well as roll control of the guidance system. **Bell Labs** and **Remington Rand** are the guidance contractors.

Propulsion and guidance systems, as well as frame, received technical approval in the STL evaluation. **Aerojet-General** manufactures both the second-stage and the first-stage 300,000-lb.-thrust liquid rocket engines.

- **Test picture unclear**—One source said all of the *Titan B* series, half of the C series and one G were to have been tested by now.

Another said, however, that only two of the C series were scheduled and that the G bird at the Cape now is a non-flight being used exclusively for compatibility checkout.

Series C tests are designed to check out guidance systems and nose cone separation. Series G are probably for re-entry.

Feeling at BMD Headquarters here is that *Titan's* troubles are administrative, not technical. STL's role, however, was to evaluate the program, not solve its problems.

Comparative military capability of *Titan* and *Atlas* undoubtedly will come up in closed session at the forthcoming congressional hearings. Some sources say USAF is ready to concede that there may be little difference between the two missiles in accomplishment of their ICBM missions, although *Titan* was intended to have 3000 miles more range, greater guidance accuracy, and larger payload delivery.

- **Closing the gap**—*Atlas* propoponents, however, say that improvements in their bird have eliminated the gap. They cite that the "operational" missiles at Vandenberg are capable of reaching any point in the Soviet Union or Red China; that *Atlas* has demonstrated a "phenomenal" accuracy at 6300-mile range (statute); and is capable of 8000-to-9000-mile range. On the *Titan* side, however, it is stated that the 6300-mile shot was a "hot-rod" version with strip-down of bird to get the range, and that guidance accuracy was not proved. As to an 8-9000 mile *Atlas* range, one person said, ". . . but with what kind of a bang in the nose?"

Proponents of *Titan* believe its advantages, in addition to providing additional operational missiles, lie in other fields. For one thing, it is said to have a space capability which *Atlas* lacks. USAF, still strongly interested in military space missions despite an Administration downhold on the subject, is counting heavily on the *Titan* in this field. The missile is at present programmed as a second stage in the *Saturn* project of National Aeronautics and Space Administration, although there have been rumors that the German team at Huntsville is pressing for a new second and third stage program.

Despite its troubles, *Titan* is backed enthusiastically by BMD and the Air Research and Development Command. Belief is that the *Titan* is technically sound and that elimination of management "bugs" in the program can restore it to schedule.

But industry's big question is when will the Air Force officially answer the claims and counterclaims about all programs? Failure to do so, industry sources point out, means inevitably that Congress will do the job for the Department of Defense.

propulsion engineering . . .

By JAY HOLMES

Hydrogen would do double duty . . .

in a nuclear-chemical hybrid propulsion system proposed by **Convair's** Krafft Ehricke. The engine would have three thrust chambers, like the *Atlas*. Hydrogen would burn chemically in the two smaller outside chambers until the small LOX tank runs out.

Then the nuclear rocket would take over. The liquid hydrogen would be directed through the hot reactor and out the big central chamber. The smaller chemical rockets and their empty LOX tank then would fall away, again just as in the *Atlas*. Ehricke said this might take place between 120,000 and 140,000′ altitude.

The promise of nuclear flight . . .

in space might be realized sooner under the Ehricke plan. For the atom doesn't begin to win the battle with chemical propulsion until we build a big booster—something on the order of the *Nova* cluster—with upwards of six million lbs. thrust.

Current estimates are that it will take more than a decade to develop a purely nuclear booster. The reason: a high-thrust nuclear rocket requires a reactor operating at temperatures far above those possible today. In short, a materials problem.

Now there is talk about a low-thrust, upper-stage nuclear rocket, which might be ready for use in 8-10 years. Under the Ehricke plan, this smaller rocket could become a booster. He figures that each of the chemical engines could have 200,000 to 250,000 lbs. thrust, and that of the nuclear engine might range from 60,000 to 200,000 lbs., depending on the space mission desired.

A $3.75-billion chemical market . . .

in missile and space vehicle development is indicated by the 1959 sales report of the Manufacturing Chemists' Association. The nation's chemical industry posted record sales of $25 billion in all categories in 1959, a rise of at least $1.6 billion over the previous record year of 1957 and $1.8 billion more than in 1958.

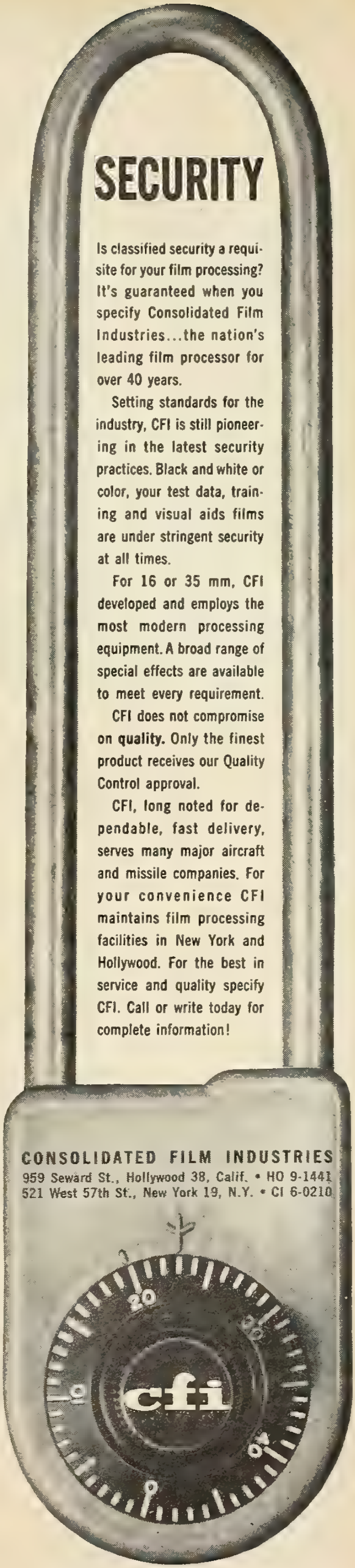
No one has ever been able to make a complete survey of the missile/space chemical market. Government security regulations and industry's jealous protection of proprietary secrets make it impossible. However, the MCA estimates that 15% of total chemical sales go for missiles and space. Hence the $3.75 billion sales total for 1959.

$360,000 contract for 19 rockets . . .

points up the success of the **Hercules Powder Co.** X248 plastic rocket. NASA, which calls the X248 *Altair*, is buying a new supply of the rockets from the Bureau of Naval Weapons for use in upper stages of a modified *Scout*, which the Air Force will use in high altitude and re-entry tests.

Hercules makes the double-base propellant grain at the Navy's **Allegany Ballistics Laboratory.** The filament-wound fiber glass case is manufactured at Hercules' **Young Development Division.**

Plastic rockets like the reliable *Altair* are under consideration as second stage of the **Lockheed** *Polaris* and as third stage of the **Boeing** *Minuteman*. NASA uses *Altair* as both the third and fourth stages of *Scout* and as third stage of *Atlas-Able* and *Thor-Able* (which launched the *Explorer VI* paddlewheel satellite last Aug. 7). *Vanguard III*, the successful shot that closed that series on Sept. 18, also used X248 as third stage.



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more about the missile week

• **White Sands, N. M.**—The Army on December 16 successfully launched a **Western Electric** *Nike-Zeus* test vehicle. The launching was the third in the early test series of the anti-missile missile development program.

• **Cape Canaveral, Fla.**—A **Lockheed** *Polaris* launched the night of Dec. 15 scored only a partial success because of a malfunction in the missile's second stage. The launching was the latest for the new 900-mile series of test vehicles.

• **Washington**—The Army awarded nearly $9 million in contracts to **RCA** for Project *Damp*—The Army's downrange anti-missile measurement program. One contract—$6,452,495—is for a one-year continuation of the program on the Atlantic Missile Range. A second contract—$2,459,409—is for program improvements.

• **London**—The authoritative Jane's All the World's Aircraft in its 1960 edition reiterated recent official and unofficial reports that Soviet missile-launching submarines already are on active service.

• **Washington**—Rep. Victor L. Anfuso (D-N.Y.), chairman of the House Space Subcommittee on International Cooperation, called for a joint U.S.-Soviet program to send a man into space. Anfuso made his proposal in identical letters to President Eisenhower and Soviet Premier Nikita Khrushchev.

• **Birmingham, Ala.**—**The Martin Co.** has received a $10.5-million contract from the Birmingham Army Ordnance District for continued R&D of the *Pershing*, 200-to-700-mile range solid-fueled successor to the *Redstone*.

• **Inglewood, Calif.**—Maj. Gen. Ben. I. Funk, commander of AMC's Ballistic Missile Center, has been picked to succeed Maj. Gen. John S. Mills as commander of the San Bernardino Air Materiel Area, Norton AFB, Calif. Mills is retiring Jan. 31. Brig. Gen. Don Coupland, deputy commander at San Bernardino, will move over to Inglewood to replace Funk. All changes are to be in effect by Feb. 15.

• **Washington**—Industry moves & expansions: **Greer Hydraulics Inc.** is relocating all its R&D and production facilities to a new plant in Los Angeles early next year . . . An East Coast plant is being opened at Hempstead, L.I., by **Furane Plastics** of Los Angeles . . . Construction has started on a 29,000-sq.-ft. addition to the main plant of **Aircraft Armaments Inc.,** manufacturer of a training system for *Sergeant,* at Cockeysville, Md. . . . **International Telephone and Telegraph Corp.** has established a new facility for R&D of special microwave electron tubes at its Advanced Development Laboratory in San Fernando, Calif. . . . and **The Gabriel Co.** is opening its new $2-million electronics plant at Millis, Mass., on Jan. 14.

• **London**—The British officially declared that their four **Douglas** *Thor* squadrons are operational. The four squadrons of 15 missiles each are deployed along the British east coast.

• **Washington**—The Defense Department has started polling 20 top contractors on their patent practices with subcontractors. The survey is being conducted at the request of the Senate Small Business Subcommittee on Monopoly, which wants to know whether it is the exception rather than the rule for prime contractors to release patent titles on R&D awards to subs.

contracts

NASA

Simmonds Aerocessories, Inc., Tarrytown, N.Y., has received a contract for designing, developing and producing prototype quantities of a recovery beacon to be used on Project *Mercury*. Subcontract from **Collins Radio Co.**

$69,163—**Kellogg Switchboard and Supply Co.,** a division of **IT&T Corp.**, for constructing an intercommunication system for the rocket launching site at Wallops Island, Va.

NAVY

$100,000—**Yardney Electric Corp.**, New York City, for manufacture of silvercel silver-zinc batteries for research and testing applications.

MISCELLANEOUS

$825,000—**Jet Propulsion Laboratory**, for research and development for wind tunnel testing.

$650,000—**General Bronze Corp., Electronics Div.,** for the antenna system for Project *STEER*. Subcontract from **Bendix Radio Division.**

$276,633—**Callahan Brothers**, San Diego, for construction of an engineering space research laboratory. Contract from **Convair (Astronautics) Div. of General Dynamics Corp.**

$132,000—Gabriel Electronics Div., **The Gabriel Co.,** for antennas to be used with the AN/FPS-35 radar system. Subcontract from **Sperry Gyroscope Co.**

$100,000—**American Electronics, Inc., Electro-Mechanical Div.,** Los Angeles, for electromechanical components. Contract from **Bendix Aviation Corp.**

AIR FORCE

Hamilton Standard Div. of United Aircraft Corp. has received a contract for 100 VA static inverters.

$5,323,140—**Radio Corp. of America,** for data link equipment for use with the SAGE and *Bomarc* systems.

$4,815,000—**Avco-Everett Research Laboratory Div. of Avco Corp.,** for continuation of basic studies applicable to ICBM reentry vehicles and other classified work.

$315,000—**American Electronics, Inc., Electro-Mechanical Div.,** Los Angeles for 20,000 variable frequency axial fans.

$174,600—**Motorola, Inc., Military Electronics Div.,** Chicago, for component parts used in DEW Line radar.

ARMY

$15,000,000—**Bendix Aviation Corp.,** Baltimore, for work of a classified nature.

$14,900,000—**Western Electric Co.**, New York City, for improvements on the *Nike-Hercules* system and repair parts. (Two contracts.)

$10,500,000—**The Martin Co.,** for continued work on the *Pershing* missile.

$8,617,624—**Ford Motor Co.,** Newport Beach, Calif., for design and development of combat vehicle weapon system

$4,500,000—**Douglas Aircraft Co.,** for kits to convert *Nike-Hercules* missiles for use at semi-mobile installations.

$3,940,000—**Radio Corp. of America,** for modification work on BMEWS radar units for use in Project *Defender.*

$3,500,000—**North American Aviation,** Canoga Park, Calif., for continuation of the *Saturn* program.

$3,437,200—**Radioplane Div. of Northrop Corp.,** Van Nuys, Calif., for target missile production.

$2,492,383—**Minneapolis Honeywell Regulator Co.,** for work of a classified nature.

$2,300,000—**California Institute of Technology,** Pasadena, for continued research and development on the *Sergeant* missile program.

$1,705,379—**Western Electric Co., Inc.,** for engineering and technical services to cover the fiscal year 1960 *Nike* field support program.

$800,000—**Chrysler Corp.,** for gyros to be used in the *Redstone* missile.

$320,850—**Radio Corp. of America,** Camden, N.J., for non-personal services in connection with the instructional courses and programs and providing instruction at Ordnance Guided Missile School.

$315,000—**Sperry Rand Corp., Utah Engineering Laboratory Div.,** Salt Lake City, for repair parts for guided missiles.

$225,625—**Douglas Aircraft Corp.,** for *Nike* repair parts.

$129,000—**AiResearch Mfg. Co.,** for *Nike-Hercules* repair parts.

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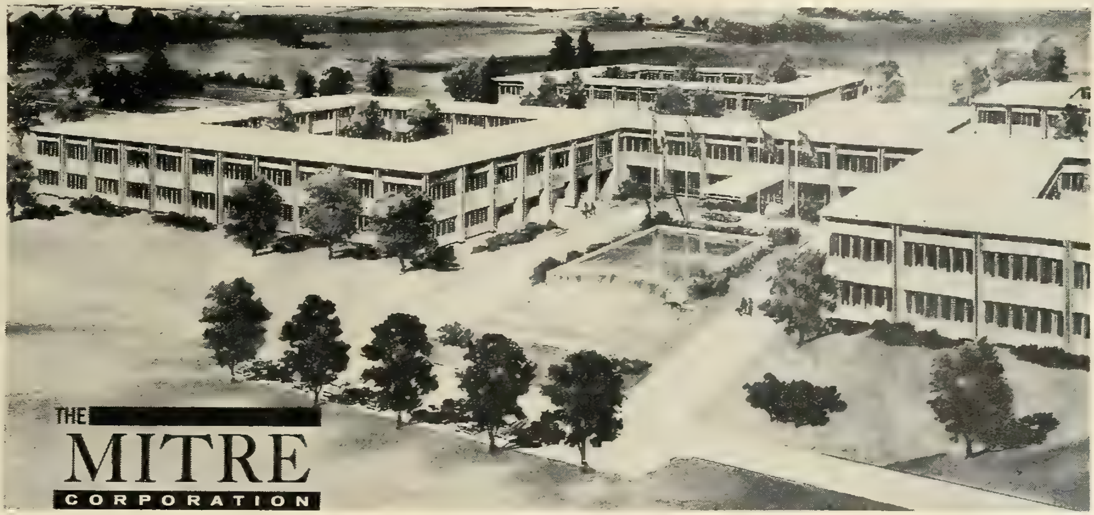

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American Chemical Society, Industrial and Engineering Chemistry Division, 1959 Christmas Symposium "Mechanisms of Interfacial Reaction," Shriver Hall, Johns Hopkins University, Baltimore, Dec. 28-29.

JANUARY

Gas Dynamics Colloquium on Electrostatic Propulsion, University of Michigan, Ann Arbor, Jan. 7.

Sixth National Symposium on Reliability and Quality Control in Electronics, IRE, EIA, AIEE, ASQC, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

First International Space Science Symposium and COSPAR Plenary Session, sponsored by COSPAR, Nice, France, Jan. 11-16.

Society of Plastics Engineers, 16th Annual Technical Conference, Conrad-Hilton Hotel, Chicago, Jan. 12-16.

Gas Dynamics Colloquium, Shock Tube Research, University of Michigan, Jan. 14.

American Astronautical Society, Sixth Annual Meeting, Statler-Hilton Hotel, New York City, Jan. 18-21.

Structure of Strong Normal Shockwaves, Northwestern University, Evanston, Ill., Jan. 21.

Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York City, Jan. 25-28.

Second Annual Symposium on High Speed Testing, sponsored by Plas-Tech Equipment Corp., Somerset Hotel, Boston, Jan. 27.

Colloquium: Research in Rarified Gasdynamics, Northwestern University, Jan. 28.

Seventh Annual Western Spectroscopy Conference, Asilomar, Pacific Grove, Calif., Jan. 28-29.

American Rocket Society, Solid Propellants Conference, Princeton University, Princeton, N.J., Jan. 28-29.

FEBRUARY

Chemical Institute of Canada, Toronto Section, Symposium on Gas Chromatography, Seaway Hotel, Toronto, Feb. 1.

Instrument Society of America, Houston Section, Instrument-Automation Conference & Exhibit, Rice Hotel & Sam Houston Coliseum, Houston, Feb. 1-4.

Sixth Annual Midwest Welding Conference, sponsored by Armour Research Foundation of Illinois Institute of Technology; Chicago Section, American Welding Society, Illinois Tech. Chemistry Bldg., Chicago, Feb. 3-4.

Institute of Radio Engineers, Professional Group on Military Electronics, 1960 Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles, Feb. 3-5.

AIEE Symposium on Engineering Aspects of Magnetohydrodynamics, University of Pennsylvania, Philadelphia, Feb. 18-19.

National Society of Professional Engineers Winter Meeting, Broadview Hotel, Wichita, Kan., Feb. 18-20.

Engineering Materials & Design Exhibition, Industrial & Trade Fairs, Ltd., Earls Court, London, Feb. 22-26.

National Association of Corrosion Engineers, Tulsa Section, 11th Annual Corrosion Short Course, Mayo Hotel, Tulsa, Feb. 24-26.

Univac Users Association, Semi-annual Meeting, Greenbrier Hotel, White Sulphur Springs, West Va., Feb. 25-26.

MARCH

Mechanical Properties of Engineering Ceramics, North Carolina State College School of Engineering, and Office of Ordnance Research, U.S. Army, N.C. State College Campus, Raleigh, March, 9-11.

APRIL

Sixth Annual Advanced Statistical Quality Control Institute, University of Connecticut, Storrs, April 3-15.

1960 Nuclear Congress: "What Will the Future Development of Nuclear Energy Demand from Engineers?" sponsored by 28 engineering, scientific, management and technical organizations. Includes: Sixth Nuclear Engineering & Science Conference; Eighth NICB Atomic Energy in Industry Conference; Sixth International Atomic Exposition, New York Coliseum, New York City, April 4-7.

American Chemical Society, 137th National Meeting, Cleveland, April 5-14.

American Rocket Society, Structural Design of Space Vehicles Conference, Biltmore Hotel, Santa Barbara, Calif., April 6-8.

American Welding Society, 41st Annual Meeting & Welding Exposition, Los Angeles, April 25-29.

Second Southwestern Metal Exposition & Congress, State Fair Park, Automobile Bldg., Dallas, April 25-29.

MAY

National Association of Relay Manufacturers, Eighth Annual Conference on Electromagnetic Relays, Oklahoma State University, Stillwater, May 3-5.

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Don't Mourn the B-70—Not Yet

When the Administration pulled the budget strings tighter and tighter, and something obviously had to give, the Air Force chose to put the B-70 program on the back burner. There it would simmer quietly, not discarded but certainly not cooking hotly, either.

Two matters of national principle were involved in the decision to cut back the Mach 3 Chemical Bomber, a 2000-mph missile platform.

One was strictly military. The present trend to use big bombers as missile launching platforms gave rise to the question of real need for such a plane. The B-52 carries the *Hound Dog*, a 400-mile, nuclear-armed, air-breathing missile. Under development is the 1500-mile air-launched ballistic missile, also nuclear-armed. With these missile adjuncts to the aircraft, is speed so important? And what of the nuclear-powered plane itself? Would it be better to leap-frog the B-70 and concentrate on atomic power?

The second question is the parallel gains or fallout which would accrue from the development of a Mach 3 bomber in the way of a supersonic transport. Obviously, whether or not America builds a high-speed passenger and cargo aircraft, someone else—probably the Russians—will. The U.S. now has a commanding position in the world aerotime market. This could be lost.

There is a third point which does not involve national principle, a more practical, a more realistic point.

Concerned in the B-70 program besides North American were six large corporations. Funding for the B-70 in 1959 was $412 million, with another $138 million for Fiscal '60. Payment to North American, which received the great bulk of this money, naturally, has not been released; but money actually spent by the associated companies went like this: Lockheed, $7.5 million; Westinghouse, $2.5 million; Chance Vought, $4 million; IBM, $58 million; Boeing, $17.9 million and Motorola, $300 thousand.

We are not ready to begin shedding tears for the B-70. We have a feeling that between the military need, the commercial need and the pressure which can be exerted by seven big corporations when millions of dollars are involved—the program is not lost.

The Air Force is far from convinced that the day of the manned aerial weapon system is past—and so are we. We are inclined to think the USAF was canny enough to reduce a program which won't stay reduced.

Military in Space

Naming Maj. Gen. Don Ostrander to head NASA's space booster program is a first big step toward getting the military back into the space program, even if it is by the back door.

Peace is wonderful—as long as you are strong enough to maintain it, and this goes for hot wars, cold wars, earth or solar systems. Space boosters may in time become as commonplace as six-by-six trucks, but right now they are the key to everything we do above the earth's atmosphere. To ignore military requirements in the booster program—as we have been doing—is preposterously foolhardy.

We don't advocate that the military take over the space program, but they certainly should be equal partners in it. When, incidentally, will we have a military man on the President's all-powerful National Space Council?

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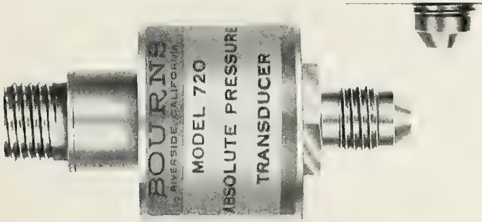

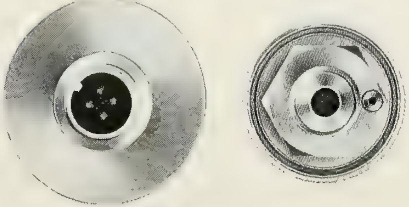

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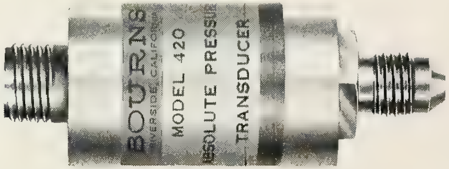

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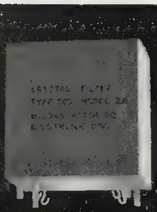

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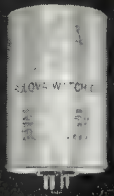

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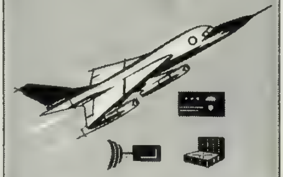

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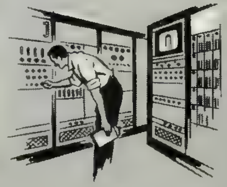

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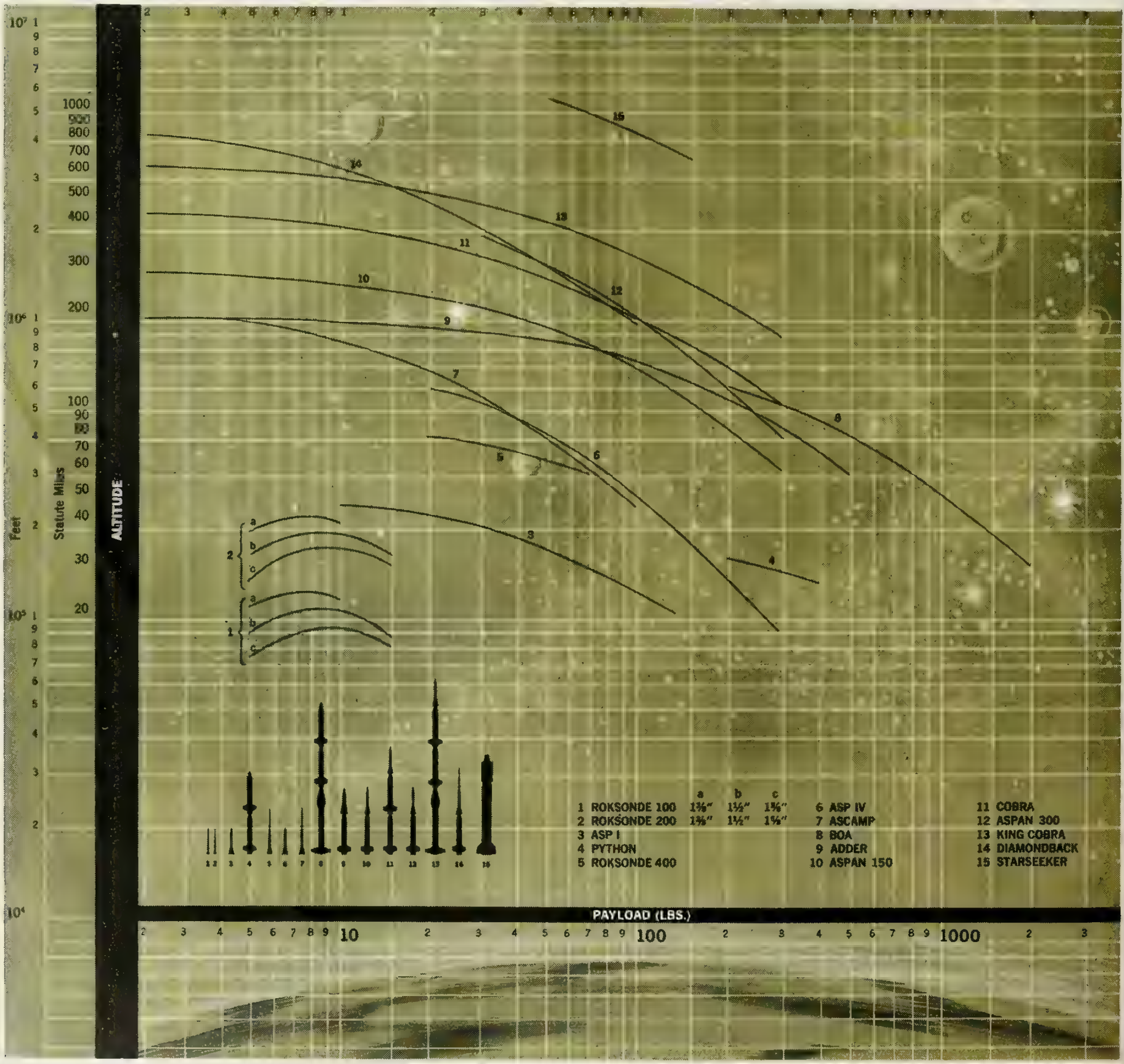

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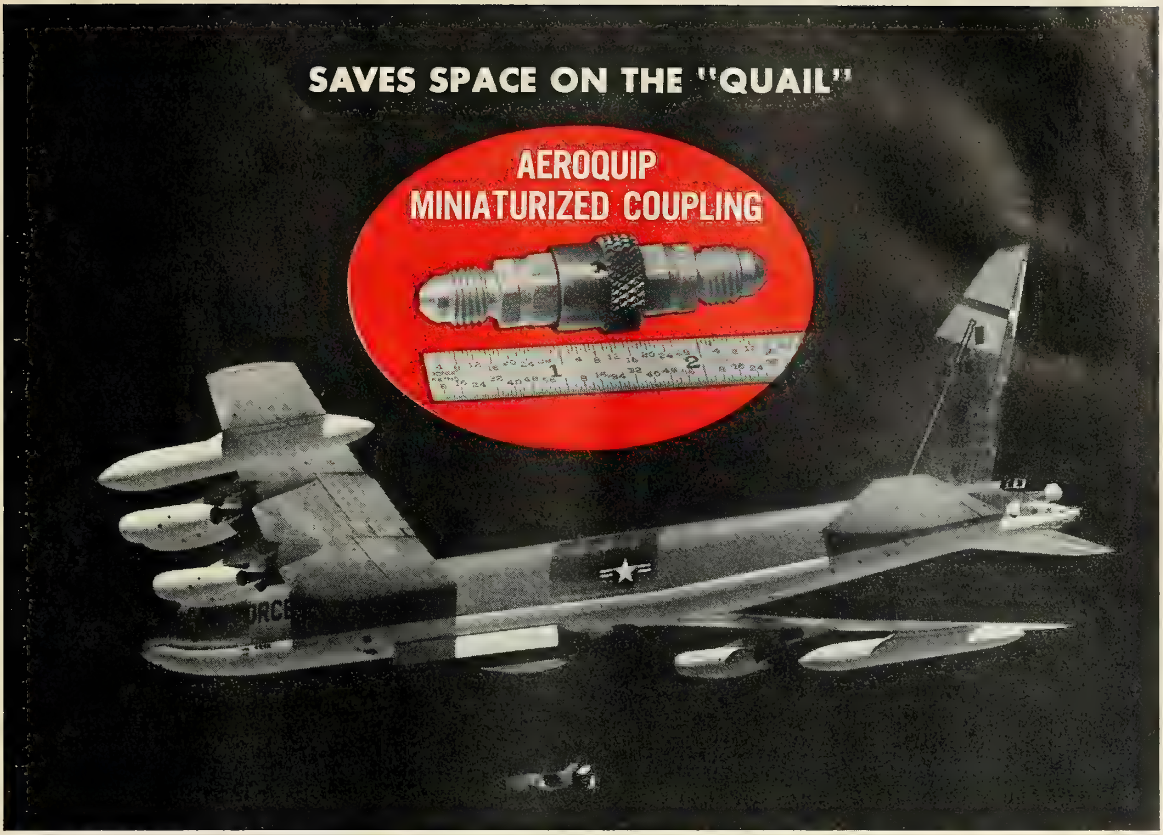

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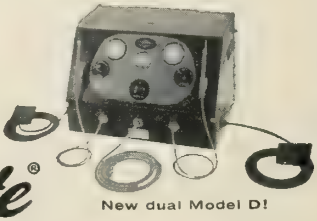

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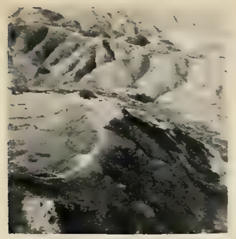
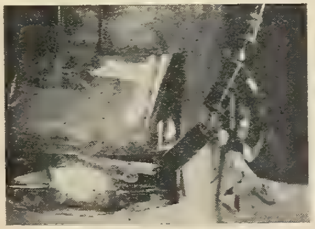


COVER: Navy's Point Arguello facilities have numerous advantages, including these rugged canyons providing safety, secrecy for launchings. A special report starts on p. 13.

MARTIN'S *Titan* management program has been changed to meet Air Force criticism, though not at the service's orders. For a report on this development, see p. 11.

FULLY wrapped thrust chamber at Rocketdyne's plant during R&D of fibreglass wrapping technique. Method has cut the weight of *Atlas* engines 25%. See story on p. 18.



TRIGATRON shown here reveals actual dumping of current and exploding of wire as performed in lab by Electro-Optical Systems, Inc. Turn to p. 20.

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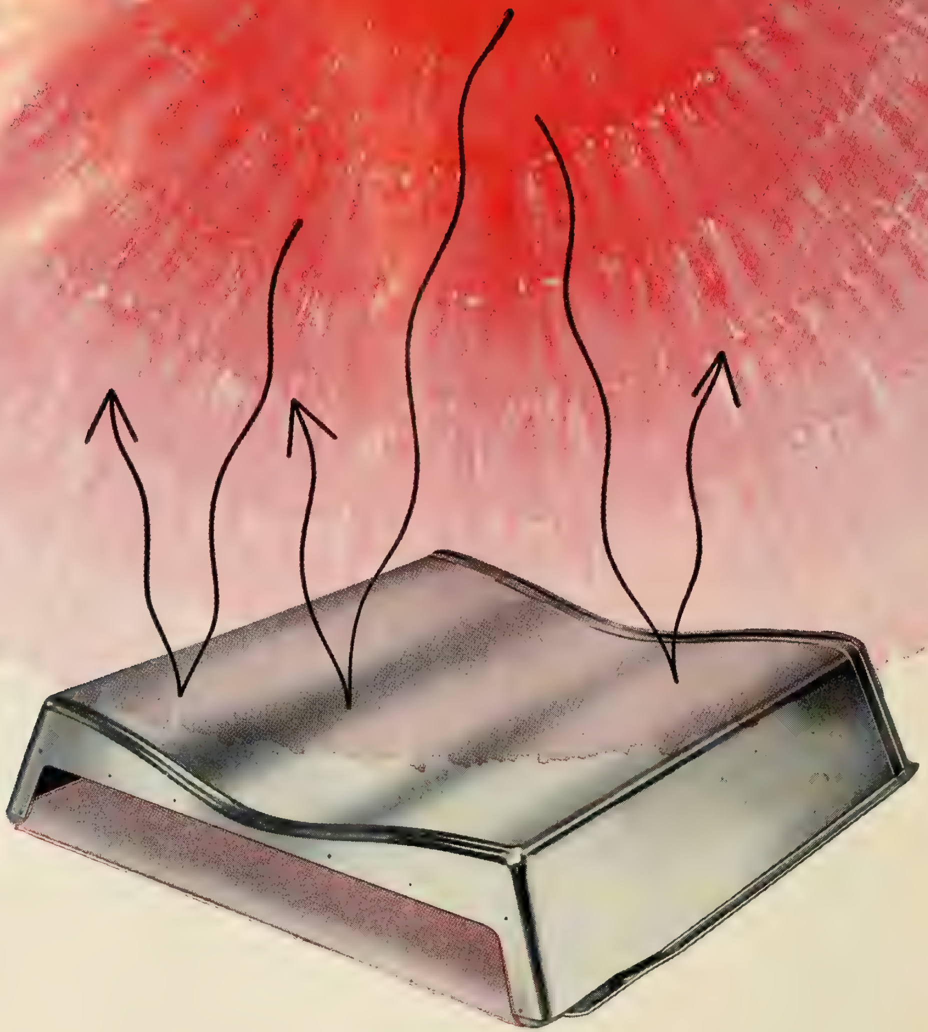
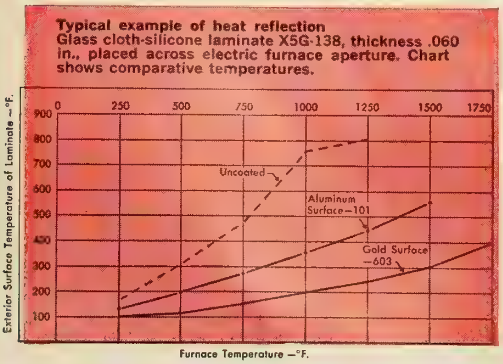


Now, reflect up to 1750°F radiant heat from SWEDLOW metallized laminates



Typical example of heat reflection
Glass cloth-silicone laminate X5G-138, thickness .060 in., placed across electric furnace aperture. Chart shows comparative temperatures.

Compound shapes—minimum weight and bulk—highly efficient reflectivity—distinguish these materials and solve the problem of resistance to elevated temperatures.

Swedlow's solution for light weight heat protection problems uses a ba of fiberglass fillers. To these are added any of an impressive variety o silicone, phenolic, epoxy, TAC polyester or polyester binders to meet specif service conditions. The resulting high-strength laminate is furnished flat o molded to any contour desired. Metallic coatings then further increase hea reflectivity and resistance. Swedlow-pioneered Type -101 aluminum coatin is now in wide use for the 200°F to 1400°F range. The more recently deve oped Type -603 gold now raises the limit to approximately 1750°F.

Swedlow research is continuing the development of many combinations fo the growing variety of aircraft, missile and electronic applications. To lear how these new materials can help solve your heat problems, contact th Swedlow plant nearest you. Or send for new literature—"Radiant Hea Reflective Laminates." Please refer to Dept. 21.

Swedlow

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Washington Countdown

IN THE PENTAGON

Dyna-Soar space gliders . . .

probably will be first launched for unpowered but manned flight tests in late 1962, according to present planning. The **Boeing** spacecraft will be dropped from B-52 jet bombers at Edwards AFB, Calif.

• • •

Dyna-Soar R&D money . . .

in the FY 1961 budget is the critical factor in the current schedule. Nearly $100 million is needed for the first stage of the big Air Force program.

• • •

Seagoing missile training . . .

for the crews of carriers and cruisers is being conducted on the coastal leg of the Pacific Missile Range. MORT—Missile Operation Readiness Testing—has been made standard program at PMR for all carriers headed for the Far East.

• • •

Missiles to the Far East . . .

are in the Army's plans for next year. Shipments to U.S. troops are expected to include **Martin** *Lacrosses* and **Raytheon** *Hawks.*

• • •

Project *Tackle* . . .

is the code name for a second polar orbiting communications satellite under development by the Air Force. It will be part of a worldwide communications satellite system that includes *Decree,* a 24-hour satellite, and *Steer,* another polar orbiter.

• • •

Reconnaissance by rocket . . .

is getting a close and very interested look by the Navy. The Navy wants a satellite or rocket that can provide "fast look" reconnaissance information for a task force at sea. Many think camera-armed rockets are a better bet than satellites for the job.

AT NASA

The new firing date . . .

for the sun-orbiting *Thor-Able IV* is about mid-January—possibly Jan. 15. **STL** hopes to have licked by then the transmitter difficulties and other payload troubles which forced cancellation of the shot this month.

A space shot sleeper . . .

using the new *Thor-Delta* may be in the works. The powerful **STL** *Thor-Delta* might be used to put a 100-pound satellite into orbit around the moon in case a planned *Atlas-Able* moon shot is permanently scratched.

• • •

Trouble for *Nova* . . .

may be on the way. NASA officials have been called on by the White House to present a run-down on the program to develop a 1.5-million-pound-thrust, single-chamber booster. The White House also has told NASA to be prepared to justify the $2-billion program.

ON CAPITOL HILL

Favorable reaction . . .

from congressmen has greeted NASA's proposed changes in the patent provisions of the National Space Act. The changes would put the agency's patent provisions more in line with those that prevail at the Pentagon—except in the field of nuclear research, where they would be similar to those of the Atomic Energy Commission.

• • •

The big missile-space battle . . .

between Congress and the Administration over the budget is considered to have been officially opened by Senate Democratic Leader Lyndon Johnson's Wright dinner speech. Johnson raised two verbal standards to rally his forces:

. . . "We cannot concede outer space to the Russians and hold leadership on earth."

. . . "We cannot indulge in the luxury of budget clerks gambling with our destiny."

ALONG EMBASSY ROW

Britain's *Black Knight* IRBM . . .

is reported to have soared to a 447-mile apogee in a recent test launching at Australia's Woomera Missile Range. The nose cone was recovered beyond Mount Eba in southern Australia.

• • •

Missile defense problems . . .

are being studied by the United States and Canada at Valcartier. A giant 14-inch hypersonic launcher is being used to launch nose cones at 7000-feet a second. The U.S. Army-built launcher is expected to double this speed when fully developed.

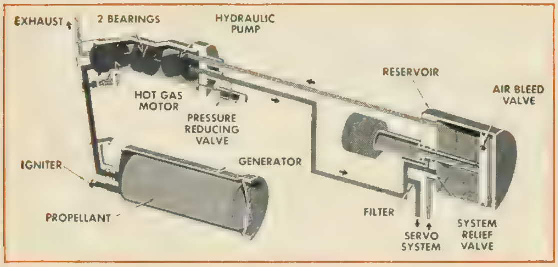
FLIGHT HARDWARE...NOW

VICKERS HOT GAS AUXILIARY POWER SYSTEMS

for missiles and spacecraft

CONCEPT

Vickers piston motors — as used in virtually all existing commercial and military aircraft — are now modified to operate efficiently on propellant-generated hot gas, or bleed gas from the main propulsion system. Minimum weight is achieved by mounting the hot gas motor "shaft-to-shaft" with a Vickers piston hydraulic pump in a common housing. The motorpump, a simple gas generator, hydraulic reservoir, filter, and relief valve are integrally mounted to form a complete Auxiliary Power System in a compact package.



DEVELOPMENT

Production line Vickers hydraulic motors have been operating on hot gas for over 2 years. Units have run on gases as hot as 2300°F without modification.

The present flight hardware was built and tested after an intensive prototype development effort. Test program motorpumps have accumulated over 100 runs each for 1 minute of operation cycle. Since the current development program is aimed at meeting known APS requirements, no limits have been established on the operating cycle duration for this type of equipment.

CONCLUSIONS

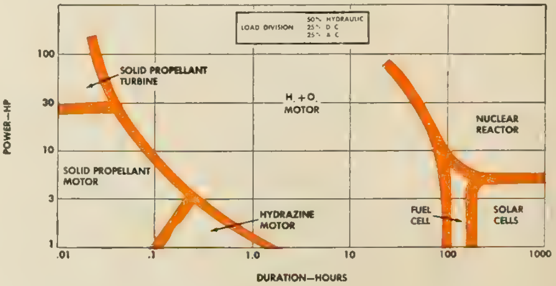
Performance and reliability goals for this concept have been met successfully. A complete hot gas APS package in the 2 - 8 horsepower range, shown above, is available within 90 days. Customer specifications for these and larger systems are invited. Write for Bulletin A-5223B.

APPLICATIONS

Because of the increasing scope of APS applications, Vickers conducted a series of studies to establish criteria for APS selection. Recent study results (published in March, 1959) indicate that for short duration operation, hot gas motors offer the best weight advantage in the 1 to 30 hp range. See curve below.

Attractive reliability and early delivery resulting from extensive use of proven hardware may extend the application of these systems to an even greater range of second and third generation missiles and spacecraft. Additional advantages include: low speed equipment (up to 10,000 rpm), convenient ground checkout, growth potential, and no alert time required.

OPTIMUM WEIGHT NON-PROPULSIVE POWER SYSTEMS



AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN

division of:
SPERRY RAND CORPORATION

8386

Industry Countdown

MANUFACTURING

Germany will cooperate . . .

in the development of the 100-mile-range **English Electric** *Blue Water*. The solid-fueled surface-to-surface missile will be used by the British and German armies, and probably by other NATO nations.

• • •

High-powered anti-tank . . .

missiles tested by the Swiss—**Nord's** *SS-10* and **Contraves'** *Mosquito*—are both reported to have ruptured 285 mm steel plate. The Swiss are conducting tests to determine the final shell configuration of their Pz 58 tank.

• • •

Sintered 50-50 moly . . .

and tungsten alloy as well as unalloyed tungsten are being extruded (at 4:1 ratio) by **Harvey Aluminum** at a Wright Air Development Division facility . . . **Atlas Corp.** estimates nonmilitary usage of uranium will exceed present domestic production (18,000 tons of uranium oxide per year) by 1973 and present U.S. reserves will be gone by 1982. AEC is buying about 36,000 tons a year from all sources for military uses, and—according to Atlas—expects this to increase in 1962-66.

• • •

January is red-letter . . .

month for contractors in the missile support and logistics area. The Air Force AMC is holding a series of three requirements symposiums. The first will be held Jan. 13-14 at New York City, the second Jan. 18-19 at Chicago and the third Jan. 21-22 at Los Angeles. NSIA, EIA and AIA, respectively, are making the arrangements.

PROPULSION

Titan non-cryogenic . . .

storable program will receive $200,000 funding by Air Force in FY 1961. Substitution of storables for cryogenics is planned for the seventh of the 11 *Titan* squadrons to be built in the next three years.

• • •

Two-step propulsion . . .

system of the IR guided surface-to-air *Redeye* "bazooka-type" missile will be developed by **Atlantic Research Corp.** The company has a $400,000 subcontract from **Convair/Pomona.**

A .67KS-600 retro rocket . . .

which successfully separated the data capsule from *Discoverer VII* nose cone had been in storage more than nine months. **Aerojet-General** says reliability of the retro was proven in advance by test-firing similar units which had been on the shelf the same length of time.

ASTRIONICS

There's disagreement . . .

among the experts on the value of NASA's passive balloon communications satellite. For one thing, many believe a sphere to be about the poorest possible shape for efficient reflection of radio beams.

• • •

Jump of 15 to 20%

in electronic test instrument production—giving it at least a $350-million volume in 1960—is predicted by **Technical Information Corp.** One-fifth of the increase is expected to be in power supplies.

• • •

Reliability conference . . .

sponsored by AIEE, IRE, EIA and ASQC will be held in Washington Jan. 11-13.

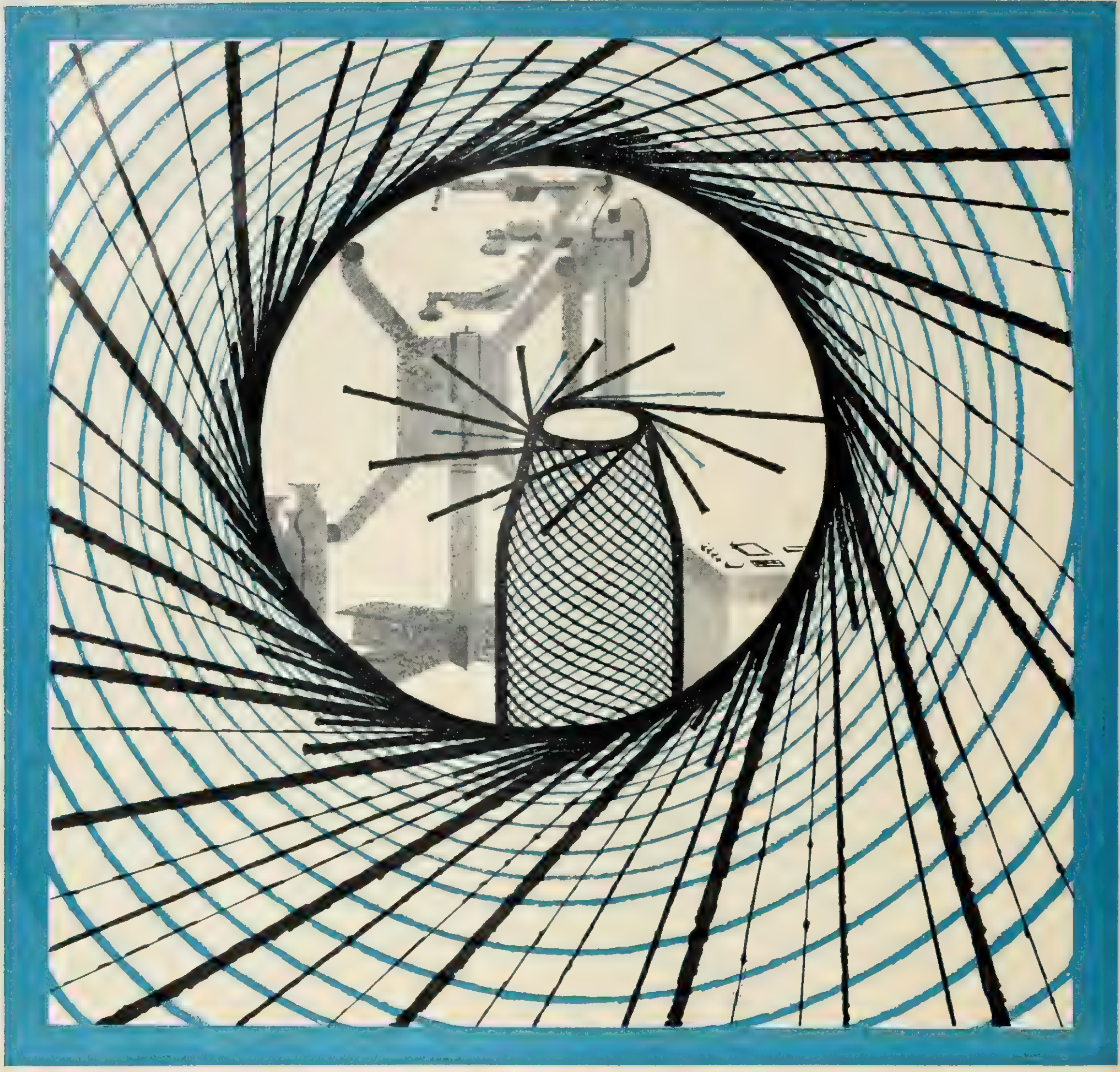
WE HEAR THAT—

Boeing and Martin . . .

will hand the Air Force's Wright Air Development Division a list of *Dyna-Soar* subcontractors shortly after New Year's. If WADD okays the list, announcement of those selected could come within a month . . . **RCA** is said to have pinpointed AFMTC telemetry range ship locations so exactly that they could replace land-based installations . . . The winner of the competition to reactivate and operate the Army's Kansas Ordnance Plant at Parsons, Kan., is **Grand Central Rocket Co.,** which will manage the production of missile motors in the 5000 lb. to 10,000 lb. class . . . **Aerotest Laboratories Inc.** is starting up a multimillion-dollar advanced propulsion division . . . and during November, 10 rockets were launched by the West Germans at Kuxhaven in experimental "rocket mail" tests. Each rocket carried 500 letters.

← Circle No. 5 on Subscriber Service Card.

More About the Missile Week on Page 43



BRUNSWICK WINDS S-D RATIOS UP TO 2,000,000!

You can get an idea of the remarkable power of Brunswick's exclusive Strickland "B" Process (SBP) from the fact that it winds fiberglass filament to a strength-density ratio of 2,000,000. (The SD ratio of high strength steels is 800,000.) The hoop tensile values of these products have averaged 200,000 psi, and their composite wall strengths range from 120,000 to 140,000 psi. SBP gives unmatched reliability and precision in the winding of structural elements, bodies, internally and externally loaded vessels and large cylinders. The process provides unusually close machine resin impregnation control, and variable control of glass density. The winding equipment shown above will produce units up to 12 feet long and 6 feet in diameter. With slight modifications, it will wind much larger units.

Get more information on how SBP can serve you. Write or call: The Brunswick-Balke-Collender Company, Defense Products Division Sales Manager, 1700 Messler Street, Muskegon, Michigan—today!

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Martin Realigns to Push *Titan*

Firm will tighten liaison between divisions; change not ordered by AF

by William J. Coughlin

DENVER—**Martin Company** is planning corporate administrative changes intended, in part, to meet Air Force criticism of its management of the *Titan* missile program.

Major shift will be one designed to tighten liaison between the company's operating divisions. This is intended to meet Air Force complaints that administration of the *Titan* program is, in effect, spread among three separate company divisions—Denver Division, Cocoa Division and Activation Division.

But reports circulating in the industry that the Air Force has ordered top-level management shifts in the Martin Company are emphatically denied both by company officials and the Air Force.

"No one now or in the past has been removed from a position at Air Force insistence," a company spokesman emphasizes.

• **False reports**—The Martin Company is concerned deeply over false reports concerning the *Titan* program now being circulated in the industry. It has retained the New York public relations firm of Ruder and Finn to handle its relations with the financial press.

Officials at Martin's Denver Division, from Vice-President and General Manager H. W. Merrill on down, freely admit that in the crash program to get the *Titan* operational, some administrative snags have developed. Top Air Force officials also concede that some of the difficulties lie at their own door.

A recent re-evaluation of the *Titan* program conducted by **Space Technology Laboratories** and USAF's Ballistic Missile Division found the missile itself technically sound and blamed difficulties on management of the program. (M/R, Dec. 21, p. 43).

Result of the study apparently will be a closer working relationship between Martin and the Air Force to eliminate some of the management "bugs" which have plagued the project.

Explosive growth of Martin-Denver Division has brought it to almost 10,000 employees within a little more than three years. Growth that rapid usually brings some management problems with it, and Martin has been no exception.

"When you build that fast, obviously you get some deadwood," General Manager Merrill says. In one six-month period, for example, employment jumped from 5,000 to 7,500.

Despite rumors to the contrary, turnover in engineering personnel at the Denver plant has been somewhat below industry average; turnover in manufacturing personnel is somewhat higher than industry average, but not unusual for the area, Martin-Denver currently is hiring at a rate of about 200 a week for a net weekly increase of about 120.

Air Force criticism of *Titan* administration has brought both Martin management philosophy and management structure into the limelight.

The change to tighten relationships between corporate operating divisions is but one of a number which the Martin Company is making, or has made, under a dynamic concept of management. Under this, management structure shifts with program growth and requirements.

• **Eight Divisions**—Martin's corporate structure is broken down into eight operating divisions: Baltimore, Orlando, Denver, Cocoa, Rias, Nuclear, Space Flight and Activation.

Activation Division, the newest, was set up last June to activate the *Titan* weapon system in the field. This division is charged with administration and coordination of all activities concerned with construction of the *Titan* training complex at Vandenberg Air Force Base, California, and the operational base at Lowry Air Force Base, Denver. It will be responsible for operational readiness of all *Titan* launching bases.

Within the Denver Division, a major administrative shift saw responsibility for *Titan* ground support equipment hived off into a separate department and into a separate plant at nearby Littleton, Colo. This, known as the Electronics Division, is in charge of Assistant General Manager G. H. Teeter.

On Sept. 21, establishment of a separate test division within the Denver organization was announced, another major organizational change. Purpose was to bring all phases of *Titan* test operations in Denver under single-point control. George A. Rodney, former chief test pilot and head of the company's flight test operations in Baltimore, was named to head the new organization.

Rodney's department is responsible for conducting operating test runs on major subsystems and the complete missile prior to delivery to flight test at Canaveral or operational sites.

Since taking over his new post, Rodney has put strong emphasis on strengthening of test discipline.

It now takes about three weeks to run a *Titan* through the Denver test program, from the time it is received by the test division until it is shipped to Canaveral. Rodney expects this will be cut to 10 days by mid-year.

Martin's Cocoa Division has the responsibility for flight testing at the cape.

• **Missile Chaperon**—Last month, in another management shift, the company instituted a policy of appointing what it calls a "missile chaperon" for each *Titan* coming off the assembly line. This engineer is responsible administratively for his missile until launching.

Aside from the advantage of concentrating responsibility, intent is to have one man so familiar with the continuity of events on each missile that he will be in a position to make knowledgeable decisions concerning it whenever necessary.

Further downstream in the program as *Titan* testing becomes more commonplace and "bugs" are worked out, this function probably will be eliminated. But for the moment, it is an innovation which Martin believes will improve management of the test program.

Martin's management philosophy, as outlined by General Manager Merrill, puts the emphasis on men who have worked up from the production and engineering side of the organization. There aren't many Harvard Business School types in Denver Division management.

Robert N. Blakey, director of the manufacturing division, for example, joined Martin in 1942 as a process planning engineer. Finance Manager

T. P. Hudock came up through the ranks as a certified public accountant. Merrill himself joined the company's Baltimore Division in 1946 as an engineer in the pilotless aircraft section.

There are even engineers in the finance division. When someone from engineering wants to argue a need for more engineers, there is a man in finance who talks his language—which may or may not be to his advantage.

While an approach which leans heavily on engineers for management talent has many advantages, it is obvious it may also offer difficulties when a management survey team shows up and wants to talk about the paperwork.

Under this evolutionary concept, administrative structure shifts with the need. When the Denver Division first was set up, for example, the production control organization was kept a part of engineering—"almost à nonentity on an organization chart," is the way Blakey describes it.

Early in 1957, production control was split out and set up on its own. A factory manager was named with full responsibility for all aspects of factory operation, reporting directly to Blakey. At this time, all work in the Denver facility is related directly to the *Titan.*

This year, the manufacturing organization has changed again. The factory manager has been eliminated and the organization is set up on a functional and project basis. There is a single manager of detail fabrication and tooling for all projects. There also is a *Titan* project manager, with control of all activities peculiar to *Titan,* reporting to Blakey. Addition of each additional project will mean another project manager.

• **Revolutionary Process**—This is an evolutionary process which the company feels frequently has been misunderstood on the outside and pointed out as "another management shakeup at Martin."

Reports of frequent top-level shifts in Martin-Denver management are belied by the facts, a company spokesman points out. Merrill has been in his present post as vice president and general manager since April, 1957. *Titan* Program Director R. G. Swop has been at Denver since 1956 and with the project from the bid stage. Engineering Division Director A. C. Hall has been at Martin-Denver for two years. Blakey was appointed director of the manufacturing division in November, 1955.

Only change in the most recent Denver master organization chart is the naming of Kermith F. Wasmuth as quality control division director to replace H. P. Campbell, who was shifted to manager of the quality control department of the electronics division.

Under what the Air Force calls its "concurrency" concept, *Titan* is being designed and produced at the same time training and operational bases are being constructed.

• **$500-million program**—Some $500-million now has been committed to the *Titan* program. Martin does not yet have a production contract for the missile, but holds a contract for a research and development program which includes demonstration of initial operational capability, including the first base and missile assigned to it.

Total cost of the Denver facility has been about $52,500,000. Of this, some $25 million is Martin capital and the remainder Air Force funds. Generally speaking, the Martin investment covers the plant complex while Air Force funds have paid for the test area, tooling and equipment.

Martin management naturally is unhappy with the troubles which have grounded the *Titan* since last May. But there also is a feeling that too many people have forgotten initial troubles with the *Atlas* and other missiles. It is pointed out that *Titan* had four very successful firings in a row, that the missile has proved itself in flight and that troubles in the program all have been ground troubles, mostly non-recurring.

"We have had no trouble with the bird itself—none," a company official points out. Test objectives were, in fact, advanced as a result of the initial launchings.

There's little doubt that even one or two successful launchings will do much to take the pressure off Martin management. Whether these can be achieved before Congress begins probing the defense budget is another question. *Titan B7A,* now on the stand at Canaveral, may provide the answer.

Titan Scoreboard

A-1—Static missile. Used to check out cells and stands at Denver and Cape Canaveral.

A-2—Damaged on test stand when erector pulled off second stage.

A-3—Shipped to Cape in December, 1958. Automatic shutdown on firing when LOX line on pump failed. LOX froze hydraulic line on erector, crew was unable to get to second-stage systems to turn them off. A-3 returned to Denver.

A-4—Shipped to Cape in January, 1959. Hard start caused automatic shutdown. Returned to Denver.

A-3—Successful flight, February 6, 1959. Tested and back on Cape within 30 days of its return to Denver. All A-series objectives met on this first flight. Program objectives advanced.

A-5—Successful flight, February 25, 1959.

A-4—Successful flight, April 3, 1959.

A-6—Successful flight, May 4, 1959. Separation of two stages tested without second-stage firing. Solid rockets used to prove successful separation.

B-1—Eliminated from program.

B-2—Static missile. Damaged when sling broke at Denver plant. Repaired for static testing.

B-3—Exploded on Denver test stand, July 3. First stage mated with second stage of B-4. Stand damaged.

B-4—First stage blew up as result of LOX tank rupture, Denver test stand, May 15. Second stage mated with first stage of B-3, exploded on test stand, July 11. This resulted from engine fire and explosion with shrapnel from engine perforating tanks. Stand damaged.

B-5—Sequence testing and static firing conducted at Cape due to lack of available stands at Denver. Exploded on launch August 14, 1959. Holddown bolts blew prematurely, missile lifted with umbilicals still attached and automatic shutdown signal turned off engine. Missile fell back on pad from 12-ft. height and exploded. Stand damaged.

B-6—Helium line tore loose, holed first stage, Cape Canaveral.

B-7—Helium sphere pulled loose in tank during static test at Denver. Support leg attached to it holed second stage.

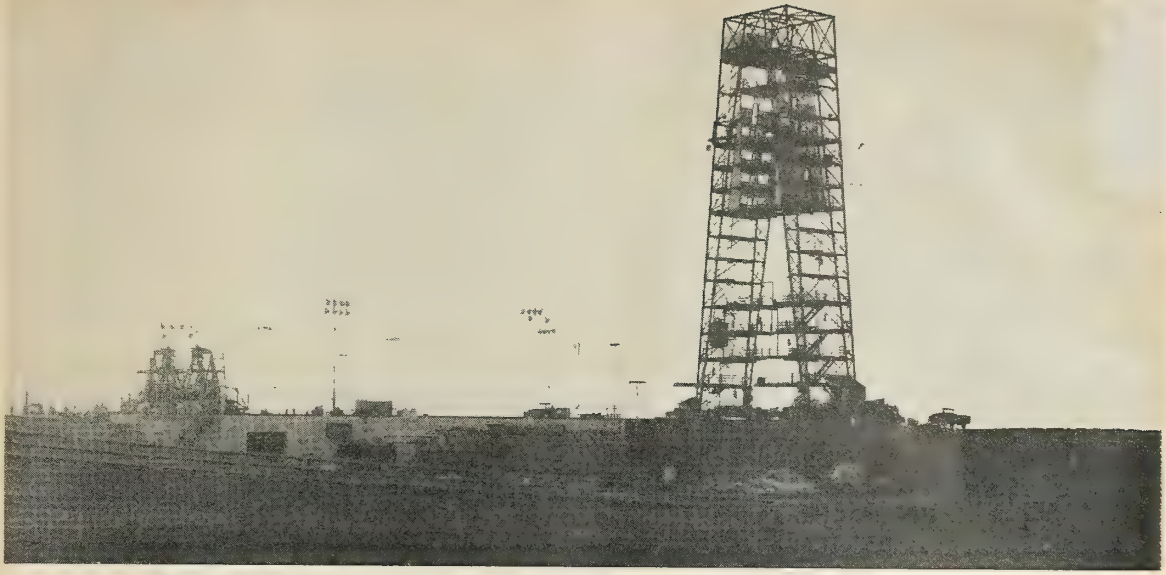
B-7—A-Second stage of B-6 mated with first stage of B-7. Now on stand at Canaveral for firing.

B-8—Failure to open valve during airlift from Denver to Cape Canaveral resulted in pressure differential which cracked tank.

B-9—Loading of LOX into cool tank resulted in negative pressure which caused tank to suck in and crack. Condition, never encountered before, later duplicated deliberately on Denver test stand. Information being disseminated to industry.

C-1—Static fired at Denver. Now being used for tests in connection with destruct package as result of C-2 explosion.

C-2—Destroyed Dec. 12, 1959, during launch at Canaveral when destruct system malfunctioned. Attributed to mechanical closing of electrical relay in destruct system, apparently due either to vibration or structural weakness.



ATLAS-TYPE GANTRY for the Air Force's secret *Samos* reconnaissance satellite nears completion at PMR's Point Arguello.

First pictures of Arguello facilities . . .

Navy Pushes for 'Perfect' Space Range

by James Baar and William E. Howard

(*This is the second in a series of special M/R reports.*)

POINT ARGUELLO, CALIF.—Less than a year ago, Rear Adm. Jack P. Monroe stood atop 2150-ft.-high Mt. Tranquillon looking out over Point Arguello's bunched hills and steep canyons to the Pacific. All around him there was furious activity.

Construction crews churned along the dark sage-covered ridges laying broad hardtop highways; to the north, the skeleton of a *Samos* gantry was taking shape against the sky; on the bulldozed crests of half a dozen hills, workmen swarmed around the white shells of buildings that would house basic instrumentation—radio transmitters, banks of telemetry equipment, radars and the main operations control center of the newly-created Pacific Missile Range which Monroe commands.

For the 55-year-old admiral, a top technical officer who began his career more than 30 years ago as a carrier pilot, it was a moment filled with both promise and uncertainty.

"Here is possibly our last opportunity to build a missile range from the ground up which will provide the necessary facilities for years to come," he said. Then, looking into the future, he added:

"These facilities must have a greater potential and be adaptable for any and all future space uses."

Today, as the heart of the PMR, Point Arguello is beginning to live up to its early promise. Through skillful planning and a tremendous expenditure of energy and money (about $200 million to date), parts of the facility are already operational.

Early next year, the first of two launching pads for the Air Force's polar-orbiting *Samos* reconnaissance satellite will be ready to receive its *Atlas* booster. *Samos* will be the first major space vehicle fired from the Point. The shot may take place in March or soon after.

The Navy also will use Arguello starting in 1960 to swing into full-scale tests of *Tepee*—its system designed to detect the launching of enemy ICBM's through high-frequency ionospheric backscatter. These tests could be tied in with the test program for the Army's *Nike-Zeus* anti-ICBM, which will be conducted from Kwajalein Atoll and Johnson Island on the western edge of the PMR.

In addition, the Atomic Energy Commission will begin its high-altitude radiation studies with *Tumbleweed* sounding rockets. And the Navy Research Lab will resume Project *Sunflare*—the launching of *Nike-Asps* to study solar phenomena.

Other programs now considered firm for the 1960-61 period include backup for **Martin** *Titan* firings from neighboring Vandenberg AFB and training of Marines in the use of anti-aircraft *Hawk* missiles.

What has PMR officials worried is whether from this point on, the range will be developed to its fullest potential for the nation's space program—or whether it will become a hodgepodge through budget restrictions and piecemeal additions.

Moreover the major factor influencing the future of PMR is the apparent decision of the Air Force to convert Vandenberg into a space R&D center (M/R Dec. 21 p. 10). As the chief potential user of PMR, the Air Force holds virtually all the cards—and a good share of the money—that

the range, the mission, the tools . . .

ADMINISTRATION BUILDING and related facilities near completion at Point Arguello. The 20,000-acre Point is the heart of the would-be $4-billion Pacific Missile Range.

will determine the range's future development.

• **Bobcats & duds**—The history of Arguello and the PMR begins in Dec. 7, 1957, with a piece of paper, a vision and a small, 13-year-old missile station at Point Mugu. Point Arguello itself was a 20,000-acre wilderness—and a somewhat dangerous one at that. Besides bobcats and mountain lions roaming through the scrub, the hills were mined with unexploded artillery shells, souvenirs from the World War II days when it was an impact area for the Army's Camp Cooke.

"Some of those duds were so sensitive a raindrop could have touched them off," a Navy officer said the other day. To clear work areas, more than 5000 acres had to be burned off and combed by demolition teams.

There were no buildings; the only roads were wheel ruts in the dirt. The chief occupants: hundreds of deer who still roam the area today watching man's elaborate preparations for leaving the planet.

• **Work plan**—Highway construction began almost immediately after Arguello was established and by last April, 15 months after its inception, more than 50 miles had been paved. (To fully service the facility, the Navy estimates another 50 miles are needed.) Work also proceeded on the first instrumentation facilities.

Prime contractor for Arguello's range support operations was given to **Federal Electric,** a subsidiary of **International Telephone and Telegraph Corp. Bendix Aviation** received the downrange instrumentation prime contract and **Texas Transportation** of Corpus Christi, Tex., the contract for providing logistic support at Kwajalein.

PMR, commissioned in March, 1958, was laid out into four sub ranges:

• An Inland Range extending from PMR headquarters at Point Mugu—90 miles south of Arguello—to Tonopah, Nev., and Dugway, Utah, eastward more than 400 miles.

• A Ballistic Range extending out into the Pacific north of Hawaii and Wake Island for impacting *Atlas* and *Thor* training shots from Vandenberg.

• A close-in Sea Test Range running 500 miles along the California coast and 250 miles out to sea where cruisers and carriers test their missiles.

• An Equatorial Range which won't come into being until a launching site is picked in the Pacific for the eastward launching of satellites into equatorial orbits.

NIKE-ASP soars spaceward from Arguello to gather data on solar flares for Navy.

Within a year after its creation, PMR Commander Monroe says, the range "developed a complete capability for handling any and all planned requirements. In fact, we were weeks ahead of schedule."

Operations actually began with the tracking of a *Thor* shot from Vandenberg on Dec. 8, 1958. But Arguello didn't get into the space business until last Feb. 28, when it provided backup tracking for the first polar-orbiting *Discoverer* satellite, also fired from Vandenberg.

• **Readying** *Samos*—Arguello today is comprised of islands of activity surrounded by acres of wild undergrowth. You reach the largest of these by driving up a paved one-time trail called Bear Creek Canyon Road. On the right as far as you can see stretch empty canyons. Beyond them lies the Pacific. Directly ahead stand the two *Samos* gantries.

One pad is more than 90% complete; the other about 70%. The prime contractor for both, under a $4.5-million contract, is **Wells-Benz Co.** of Phoenix, Ariz. **H. E. Robertson Co.** fabricated the 100-foot-tall railed gantries which stand on a high slope about 600 yards apart.

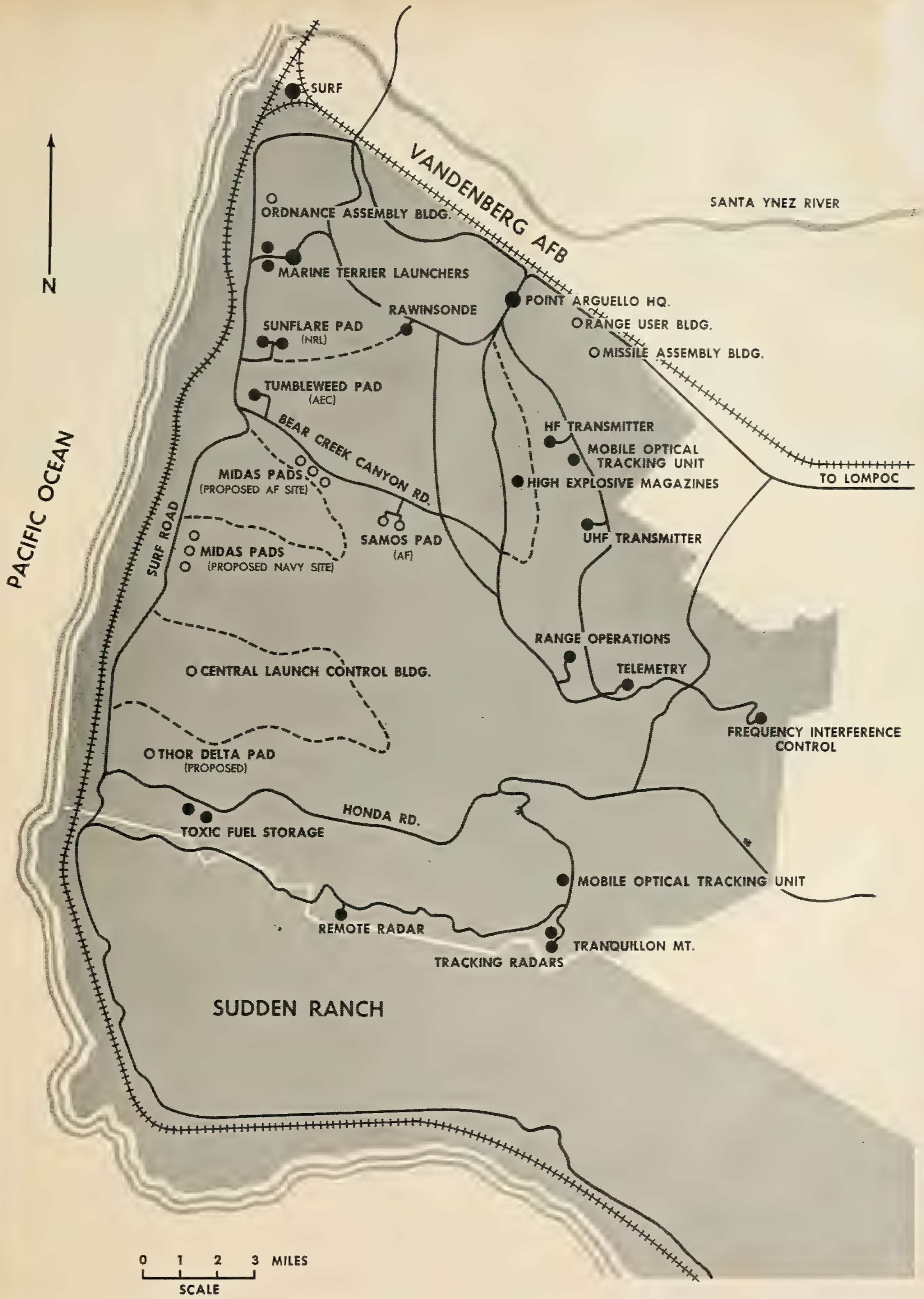
All instrumentation and other equipment already has been moved into place in the blockhouse that serves both pads. It is now being wired and checked out. Lights have already been installed around Pad No. 1 and the fueling system is in place.

Adjacent to the blockhouse, contractors have set up a village of dozens of trailers and prefabricated shacks—ready to be moved away within the next few months.

The sprawling, almost-completed Range Operations Building stands on a hilltop about two miles farther inland. The Telemetry Building is nearby. Both are partly operational.

PMR data acquisition facilities are being expanded by the installation at Arguello of 20 **NEMS-Clarke** telemetry receivers. Some of these will be used for storage of data on magnetic tape while others will be used for both storage and display. The new equipment will supplement 15 FM-FM (AN/-UKR-5) telemetry receiving stations and three PDM-FM receiving stations located at Point Mugu and San Nicholas Island which lies just off the coast.

Data links are being set up so that



PRESENT AND PLANNED facilities give Point Arguello basic launch-tracking capability on which Navy hopes to build the world's greatest space range. Solid dots indicate existing facilities; others are proposed or under construction. Solid lines indicate improved roads and dotted lines show location of trails. Sudden Ranch is leased by Navy from private owner.

ARGUELLO RANGE OPERATIONS are conducted from new sprawling building atop one of the Point's many hills.

telemetry can be displayed simultaneously at the Arguello Operations Building, Point Mugu and other range points.

Arguello's long-range tracking radars are being installed south of the Range Operations Building on top of Mt. Tranquillon—highest place on the Point. The instrumentation includes two of **RCA's** newest long-range radars—the FPS-16. Similar radars are being installed at Point Mugu.

Optical tracking equipment at Arguello as well as Point Mugu, San Nicholas Island and downrange sites includes **Askania** Model KTH tracking cinetheodolites. These permanent installations are supplemented by Askania KTH 41 transportable cinetheodolites and mobile optical tracking units.

Bowen RC-2 and CZR-1 acceleration cameras are installed on mobile mounts for measuring the acceleration of surface-launched missiles. Optical miss-distance equipment also is available downrange.

• **Ships for tracking**—PMR's land-based tracking facilities are further supplemented by three ships—the Joe E. Mann, Dalton Victory and Haiti Victory. A fourth ship will be added to the range radar fleet with the conversion of another Victory Class hull under a soon-to-be-let $10-million contract.

All three ships now in operation provide tracking facilities down-range. However, the Dalton and Haiti are primarily designed for recovery work and determining impact points of re-entry vehicles.

The PMR ships are supporting the *Discoverer* program along with the Air Force's attempt to recover re-entry capsules with "air snatch" nets attached to C-119's operating out of Hawaii.

The Navy says it is now offering as services to all range users:

• Area clearance, range control, range liaison (with users), ground safety, instrumentation, meteorology and photography.

• Administrative flight operations.

• Public works technical engineering, including limited design work, construction, alteration, repair, utilities and transportation service.

• Material procurement including supplies, travel, shipping, storage, technical classification disposal and clothing and small stores storage.

• Administrative, communication and telephone service.

• Security and fire protection services.

• Medical and dental services.

• Military discipline, legal, chaplain, service information office, recreational and educational services.

All flight operations, logistic support, community and recreation services—including payment of personnel—is done through Vandenberg for Arguello. Vandenberg also provides housing for the Point's 250 Navy personnel and 81 Marines. Because of over-firings, no living facilities are currently planned to be built at Arguello. Instead, a BOQ, enlisted men's barracks and 97 units of Capehart housing are being built at Vandenberg for the Navy.

• **Spotting the bullseye**—For the Marines who train twice yearly at Arguello with *Terrier*, PMR provides target drones, and recovers them. It will provide the same services for the Marines when they begin training with *Hawks* next year.

As backup to *Thor* and *Atlas* training shots from Vandenberg, Arguello is in charge of frequency interference control and well as supplying data reduction and information on warhead impact. *Sofar* and *Loran* are used for pin-pointing impacts in PMR's bullseyes north of Hawaii and north of Wake.

For the *Discoverer* program, Arguello predicts the area of impact for booster fallout, and will do the same for *Samos* in addition to the usual tracking and other services including data reduction.

Arguello is now completely in charge of range safety under the latest Air Force-Navy agreement covering R&D missile and space operations on the West Coast.

The agreement, reached recently amid the running Air Force-Navy struggle for the top role in West Coast space activities, turned over the destruct button to Arguello for all launchings into the PMR—except for *Atlas* and *Thor* training shots.

Arguello also is in charge of such safety and security matters as stopping Southern Pacific trains from running through the Arguello and Vandenberg.

• **Billboard space?**—One Navy wag has suggested that at least the security problem posed by the railroad might be profitably solved by building billboards along the entire right of way and selling space to missile manufacturers.

One of the main advantages that Arguello has to offer besides its various services is its location and its rugged topography. Several canyons provide sites for launching pads from which missiles and space vehicles can be fired in secrecy and safety.

The nearest settled area of any size is 10 miles away at Lompoc. And the high canyon walls provide revetments that would protect other installations at the Point.

The Navy considers some of the canyons capable of housing launching pads large enough to handle boosters ranging from 6 million to 10 million pounds of thrust.

If Navy plans for building launching pads for giant boosters materialize, PMR would become the greatest space range in the world. The plans are part of the Navy's overall $4-billion program for PMR. The program calls for spending half of the money during the next four years; the rest during the following decade.

A key part of the plan calls for construction of huge launching pads on an island along the equator to make it possible to place multi-ton payloads into equatorial orbits. These include 24-hour stationary satellites and the assembly of space platforms which require a rendezvous orbit.

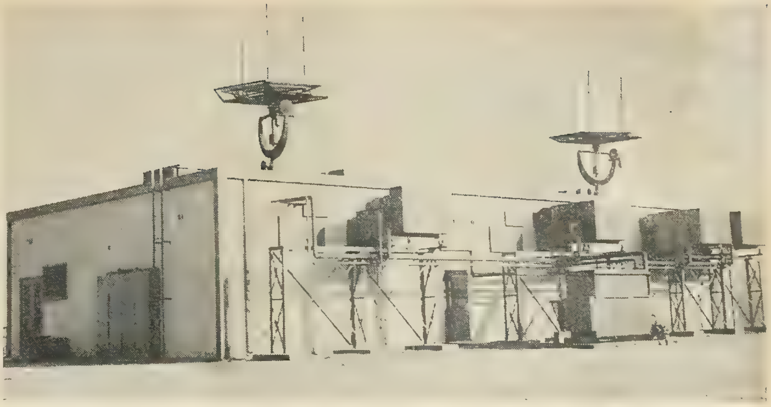
Another key phase calls for the construction of hard-line communications throughout the vast range. Some range officials consider this one of the range's most pressing needs, but they hold out little hope in the current tight-budget era of getting the some $750 million that would be needed to do the job.

Since the range's commissioning, only some $200 million has been authorized for its development—a small down payment on the overall plan. Funding is not expected to improve in FY 1961. The new budget is expected to provide less than $100 million for PMR.

This means that the Navy will continue to be a long way from achieving its goal of building a missile range that would provide the nation's space needs for years to come. Instead, budget restrictions are forcing the construction of the range piece by piece as expediency dictates.

Officials in favor of the piecemeal approach under any circumstances argue that it prevents the Navy from installing "gold-plated toilets." Opponents argue that whatever economies might result from day-by-day development will be lost in the long run because a far less effective range will result.

To date the economizers are winning the day. The deer and mountain lions can be expected to abound in many parts of Arguello for some years to come.



TELEMETRY BUILDING is situated on a hilltop not far from Range Operations. Deer often graze nearby in empty canyons.

REMOTE RADAR building houses equipment for conducting surveillance of both sea and air to provide clearance for missile launchings.

TRACKING RADAR building on top of 21,500-foot Mt. Tranquillon houses newest long-range radars and other tracking instrumentation for PMR.

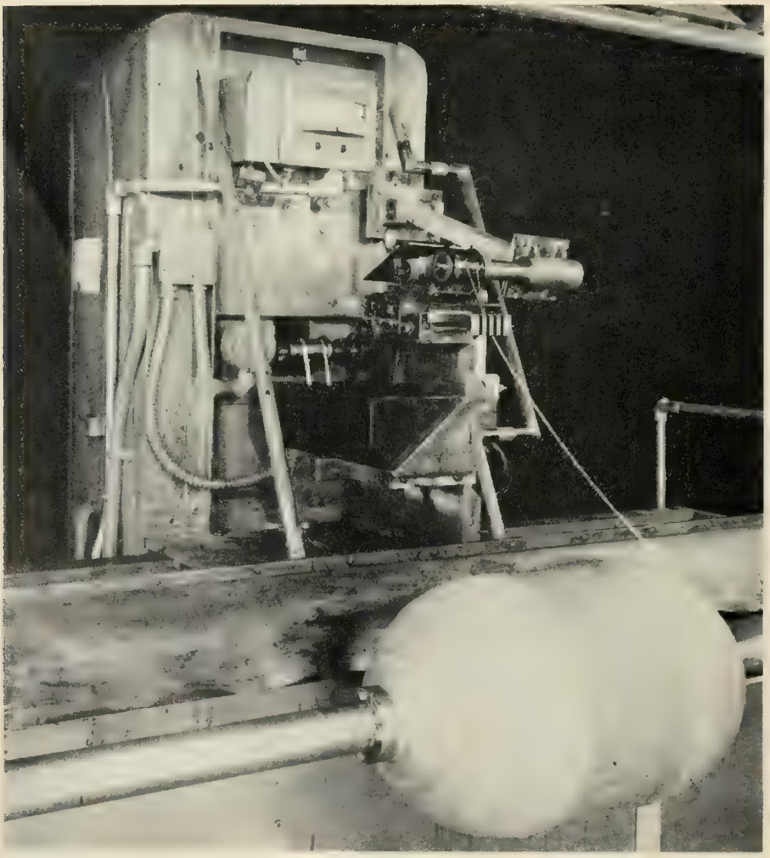
Fibreglass Wrapping Lightens *Atlas*

Rocketdyne achieves 25% savings in weight and cost of Atlas thrust chambers, and is developing the technique for use in solid powerplants as well

by Frank G. McGuire

Canoga Park, Calif. — A new method of gaining strength and light weight for liquid-rocket engines, solid-rocket motors and pressure vessels is under advanced development at **Rocketdyne,** after being approved for *Atlas* production engines. Primarily a fibreglass wrapping process, the method has resulted in great weight, cost and time savings.

On the *Atlas* engines, 25% weight reductions have been achieved over the previous method of using steel restraining bands around the engine's combustion chamber. This saving, amounting to approximately 56 pounds, could be increased by further reducing the amount of winding used, a possibility considered quite feasible. Cost savings are also in the neighborhood of 25%.



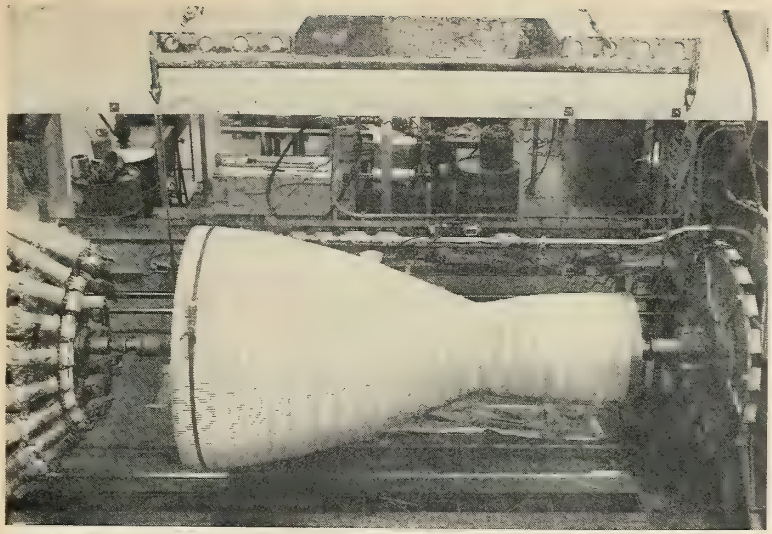
HELICAL WRAPPING is applied to a test specimen at the Rocketdyne plant. Stresses of 120,000 psi have been attained with the method as used for solid motors.

Ultimate yield stresses of 230,000 psi have been attained on the specimens of unidirectional winding similar to that used on the *Atlas* thrust chamber, and stresses of 120,000 psi are being attained with helical winding as used with solid-propellant motors and pressure vessels.

- **Time consuming**—Brazing and welding the steel bands to the combustion chamber was an operation consuming a couple of weeks. In contrast, the winding process can be completed, from initial preparation to final curing, in eight hours.

The process involves winding a glass filament roving, impregnated with an epoxy resin, around the combustion chamber, and introducing longitudinal sections of tape of similar material. The tape is loosely woven Roving with a minimum of cross filaments. (Roving is similar to a yarn thread, but without the twist. Neither a woven tape nor a twisted yarn is used because strength is reduced through weaving or twisting.)

Applied to the *Atlas* chamber in varying thicknesses, the material averages approximately $\frac{3}{16}''$ thick. Curing is accomplished in an oven at 200° to 300° for two hours. Experiments being contemplated would determine the feasibility of fabricating liquid-propellant chambers completely of fibreglass filament winding, with an erosion-resistant insert in the throat. Present methods still utilize the tubular



BOOSTER CHAMBER for *Atlas* waits in glass wrapping machine prior to the start of operations. Process was also used on *Thor, Jupiter* and *Navaho* during R&D work.

structure necessary for regenerative cooling.

On solid-propellant motors and other pressure vessels, a helical winding method is used, rather than the unidirectional winding of the *Atlas* chamber type. This makes it possible to hold in the head closure more efficiently. The helical winding, in figure 8 form, may achieve weight savings up to 50%.

• **Casings, too**—Entire solid-motor casings, complete with nozzle, can be wound, using a soluble jig or form which is removed before casting the propellant into the casing.

Any metal attachments necessary to operation may be wound into the filament with complete structural integrity. End closures on pressure vessels are wound into the filament and bonded with the resin. Failure at those joints is not a problem.

During winding, a firm jig is maintained within the chamber to prevent collapse of the coolant tubing under filament tension. Rocketdyne now has a winding machine at Neosho, for production engines, and a number at Canoga Park for R&D work.

The lathe-like circumferential winding machine at Canoga Park has the chamber rotating under a horizontally traversing arm which feeds epoxy-impregnated filaments onto the chamber at a predetermined rate. Rotation speed of the chamber is also controllable, permitting complete control over the amount of filaments applied on each pass of the traversing arm.

The helical winding machine is similar, with the added capability of having a controllable helix angle during application. On both machines, the filament is held on spools at the rear of the machine, then drawn through the impregnating resin before application to the form.

Preparation for winding the chambers involves sand-blasting the surface to be wound, then coating it with a resin to insure proper bonding of the filament winding to the tubes. After application of the filament, curing is accomplished. Physical size of the parts wound is limited only by size of the processing equipment.

Originating in 1954 as a development proejct, the filament winding process has been applied to *Thor, Jupiter, Atlas* and *Navaho* chambers during R&D development. However, *Atlas* is the only one that is now in full production.

Rocketdyne engineers foresee a greatly expanded use of filament winding, especially in rocket engine applications, and other fields. The day is also seen when liquid-rocket chambers as well as SPR nozzles will be fabricated solely of a reinforced plastic erosion-resistant liner that is filament-wound on the outside for strength.

ABMA Transfer Plan Is Readied for President

by an M/R Correspondent

HUNTSVILLE, ALA.—A proposed plan for transferring a major part of the Army Ballistic Missile Agency to the National Aeronautics and Space Administration is expected to be laid before President Eisenhower before the month's end.

The plan, worked out by a joint Army-NASA task force in Huntsville and Washington, is expected to get a Department of Defense stamp of approval before it is handed to the President. While final details of the switch are being hammered out in Washington by NASA Administrator T. Keith Glennan and Maj. Gen. August Schomberg, commander-designate of the Army Ordnance Missile Command, general agreement on the transfer has been reached.

The President probably will present the transfer plan to Congress soon after that body reconvenes Jan. 6.

If all goes well, and Congress does not disapprove the transfer (approval is not required), actual transfer should be made in mid-March, with NASA in full operating control by the beginning of the new fiscal year.

Basically, the proposal calls for transfer of the 4300-man Development Operations Division of ABMA, headed by Dr. Wernher von Braun, to NASA —along with necessary physical facilities such as laboratories, office spaces and test stands, to enable NASA to meet on a self-sufficient basis its requirements for super-booster development.

ABMA will not be abolished as an agency of the Army, but will be continued to handle development of various military weapon systems as may be required. These would include the *Pershing* system, and the continued phase-out of *Jupiter* and *Redstone* missiles. It is possible, one source said, that other systems will be assigned to the agency. One proposal, for instance, calls for some of the systems being developed by the Army Rocket and Guided Missile Agency to be transferred to ABMA to "equalize the development load." ARGMA, now handling more than a dozen systems, would become primarily an air defense weapon system development agency, handling the *Nike-Zeus,* the *Nike-Hercules,* and smaller systems such as the *Redeye, Hawk* and *Mauler.*

• **Step-up likely**—If DOD approval is received, the net result probably will mean increased activity at Redstone, since both NASA and the Army would need additional personnel to remain self-sustaining.

Included in the transfer proposal, it was pointed out, are plans for "cross-buying" of services between the Army and NASA, to avoid needless duplication of effort.

It is in this area that details remain to be worked out—such as who will provide for NASA security, transportation, housekeeping and telephone service, since NASA has no such facilities at Huntsville. Also, the Army will have a continued need for some of its major facilities, such as the complex, multi-million-dollar computations laboratory, and its 15-story static-test stand (now modified for the *Saturn* booster), although not on a full-time basis.

I_{sp} May Be Upped by Wire Explosion

Company believes this propulsion method can provide more power than most proposed electrical systems offer; other uses seen in communication, attitude correction

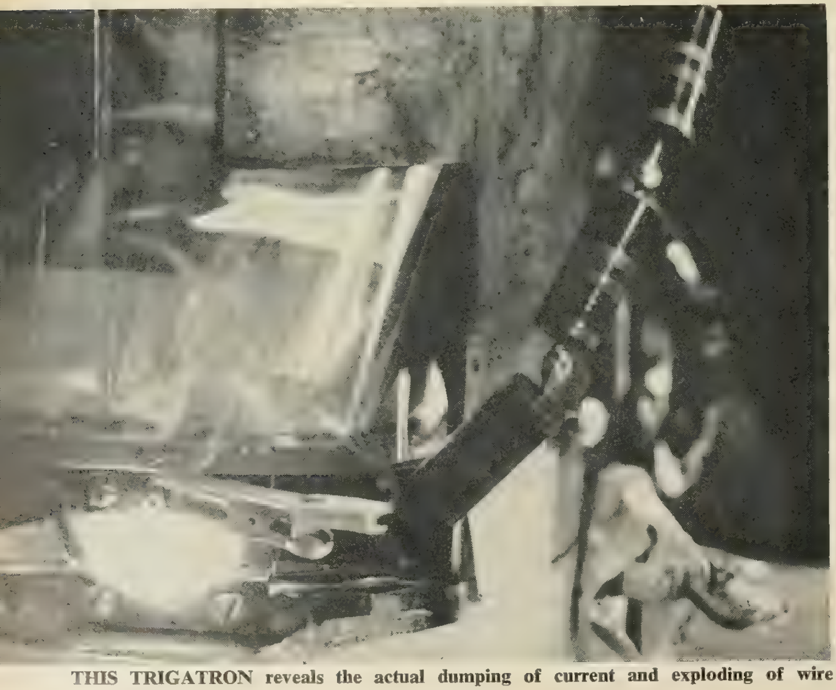
PASADENA, CALIF. — Electrical explosions of fine wires may provide outer space vehicles with 2 to 10 times the specified impulse of present chemical propulsion systems.

This is only one of several applications proposed by **Electro-Optical Systems, Inc.,** out of a year-long basic research study of exploding wire techniques in fuze initiators and detonators conducted for U.S. Army Ordnance.

Such impulses conceivably could increase propulsion capabilities for space vehicles, particularly for missions from the atmosphere's outer edge to the moon. The system might also be used for satellite attitude correction. The company now feels that such a propulsion method can provide more thrust for the amount of power consumed than many currently proposed electrical propulsion systems.

Use of exploding wire phenomena to determine reaction characteristics of surfaces struck by hypervelocity objects would enable scientists to obtain high-speed impact data not presently obtainable. Vapor or plasma emanating from the exploding wire could be accelerated to 20-30 kilometers per second—a speed far greater than anything presently in laboratory use.

Other uses proposed by EOS include high-intensity light sources for communications purposes; utilization in studies of particle impact against various surface types; possible use as fusion for thermonuclear energy generation, and light for photochemical reaction.



THIS TRIGATRON reveals the actual dumping of current and exploding of wire as performed in the laboratory by Electro-Optical Systems, Inc.

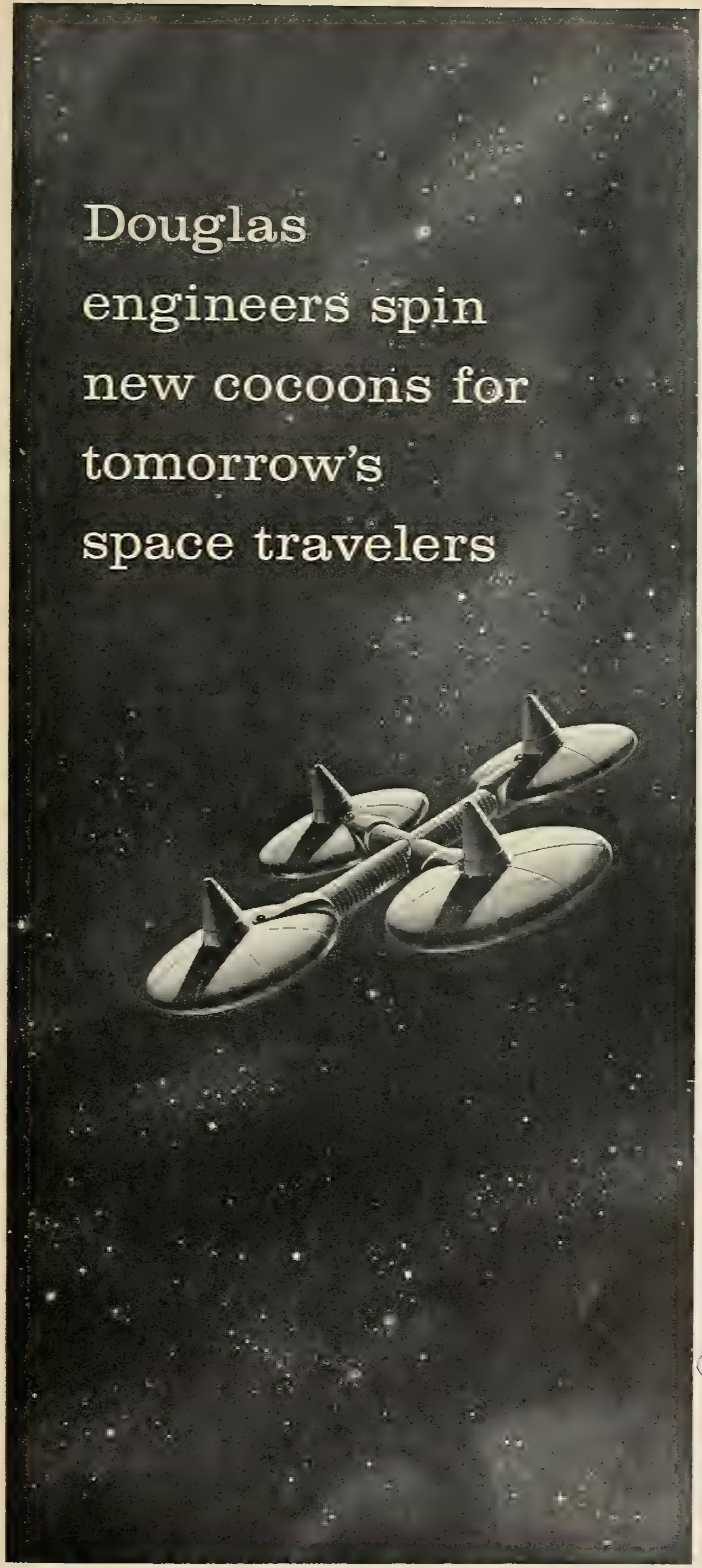
- **Fast switching**—Key to the above applications lies in heat generated and the high amount of thrust producing energy obtained by fast switching of large amounts of current into the wires in millimicrosecond time. This technique has enabled EOS to place many times the material's vaporization energy into the wire.

Temperatures up to 100,000°C and pressures in the megabar range have been obtained. Specific impulses of 1000 seconds have been achieved by exploding several wires at once, and a 1000-5000 second range appears possible.

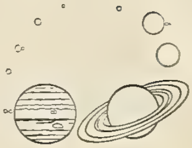
The exploding wire technique at EOS is accomplished by charging electrical energy sources to many kilovolts and then suddenly switching current through the wire. Actual switching is triggered first by a hydrogen thyratron which activates a trigatron that actually dumps current into the wire by means of a triggered air spark gap.

Materials used in experiments include: aluminum, iron, copper, gold, silver, nickel, tungsten, molybdenum, tin, titanium, zinc, cadmium and bismuth. Test wires measure about one mil in diameter and ¼-in. in length. A capacitor of from 0.002 to 0.02 microfarads charged to 10-20 kilovolts is suddenly discharged into the wire where the entire circuit inductance is from 0.1 to 0.03 microhenrys. Voltage is switched across the wire in about seven millimicroseconds and the vapor process duration ranges from 50 to 100 millimicroseconds.

- **Dwell time**—Current dwell phenomena has been encountered in the wire explosion. Following the initial vaporization stage, current conduction is reduced to a low level. But voltage remains across the gap because vaporization is completed before the capacitor charge flows out completely. After a given time there is a resurge of



Douglas engineers spin new cocoons for tomorrow's space travelers



Space researchers in human factors engineering utilize latest discoveries of medical science

Each time a space traveler leaves home (earth) he has to be completely wrapped in a special environment. He needs it to survive under alien conditions such as extreme heat and cold, high vacuum, cosmic radiation and tremendous G forces.

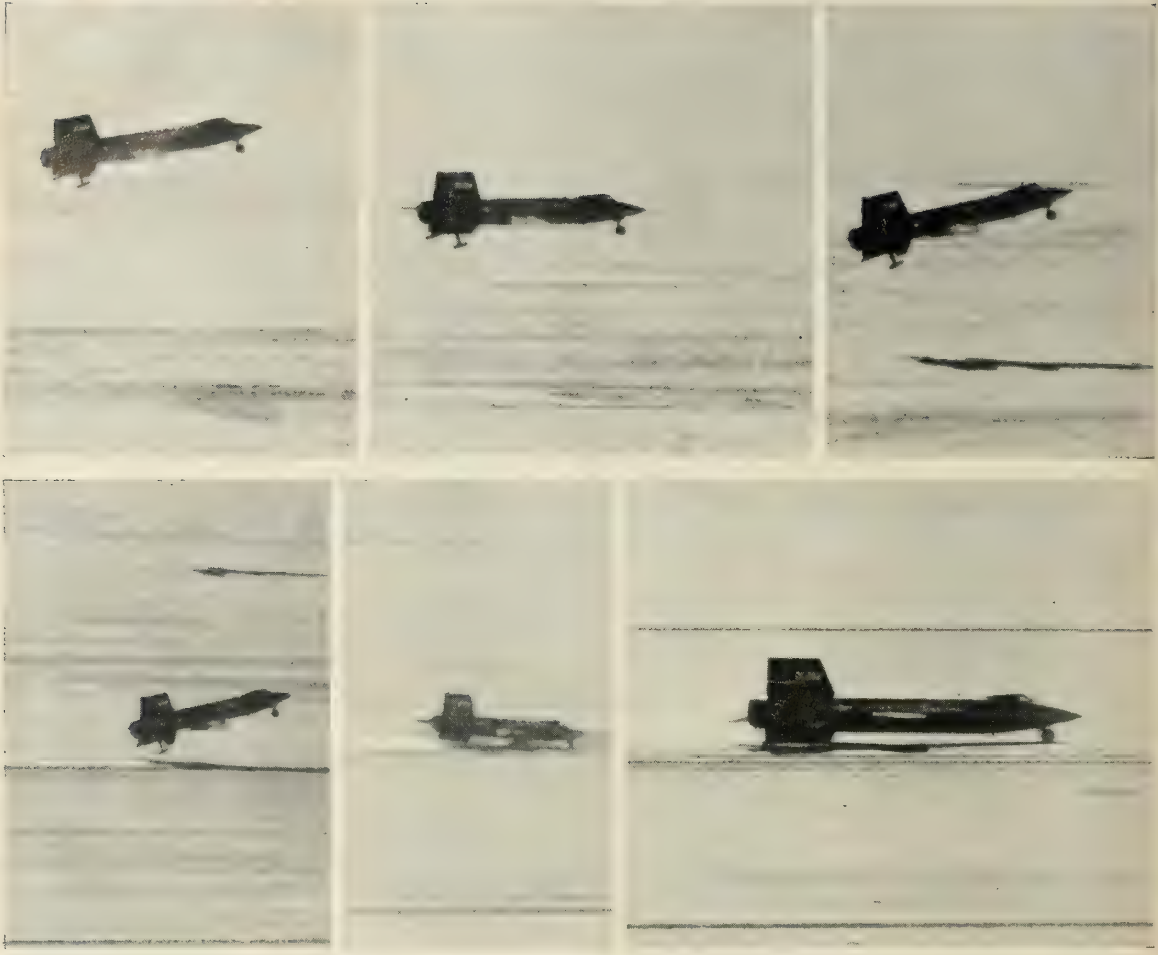
At Douglas, life scientist research over the past ten years has explored more than *forty* basic factors relating to human survival in space. Douglas engineers are now completing — at military request — a careful survey of conditions that will be encountered en route to and on other planets. They are also evolving plans for practical space ships, space stations and moon stations in which men can live and work with security thousands of miles from their home planet.

Out of these research activities and those made by companion workers in this field has come new knowledge of great medical importance . . . even to those of us who are earthbound.

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • TRANSPORT AIRCRAFT • AIRCOMB • GROUND SUPPORT EQUIPMENT

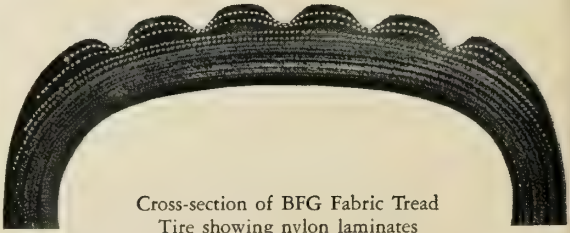
B.F.Goodrich



Fabric Tread Tires invented by B. F. Goodrich help land X-15

When the North American X-15 comes in for a landing, the B.F.Goodrich Fabric Tread Tires on its dual nose wheel touch down at about 200 mph. As X-15 comes to a stop, these special tires must withstand tremendous friction and heat build-up. Yet they can take this rugged pounding because nylon laminates are sandwiched right into the tread stock. These laminates reduce distortion under load, equalize modulus between tread and carcass and check "shock wave" formation.

The same construction now goes into BFG tires for today's newest commercial jets. For further information on these and a variety of B.F.Goodrich products you can use in space, in the air and on the ground, write to *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Co., Dept. MR-129, Akron, Ohio.*



Cross-section of BFG Fabric Tread Tire showing nylon laminates

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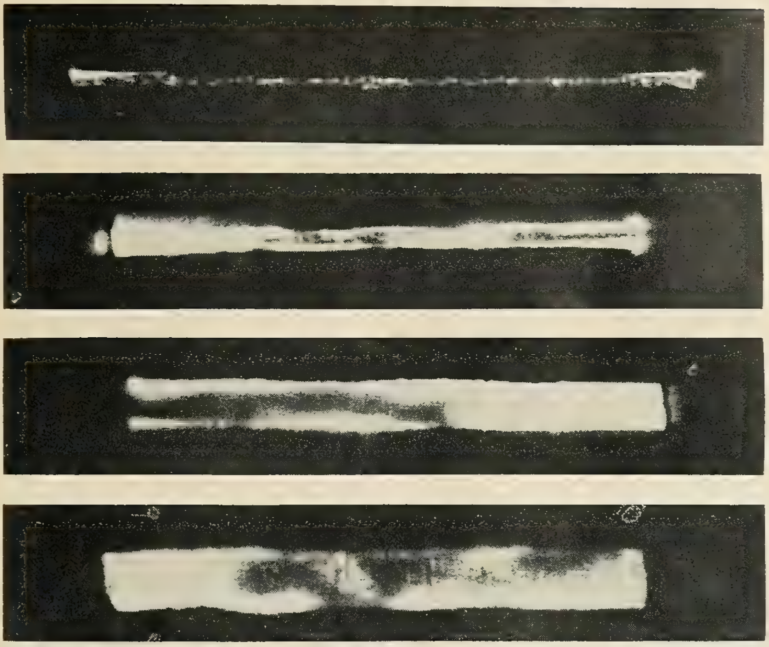
special instrumentation . . .



SERIES ILLUSTRATES reaction of exploding aluminum wire 3, 8, 32 and 45 millimicroseconds after induction of current. Wire was 1 mil in diameter, 3/16" long.

current conduction by the restrike of an arc.

Placing larger original voltages across the wire reduces dwell time to where it may also be merged into the initial current conduction phase.

Special instrumentation devices have played a large part in the EOS program. The company is believed to be one of the nation's first organizations to record simultaneous measurement of both voltage and current across the wire with a resolution of a billionth of a second. This has enabled the company to determine power input and wire resistance and has revealed a variety of characteristics of the particular material under study.

An EOS-developed Kerr Cell camera with an exposure time of 5 millimiscroseconds is used to photograph the explosion period and provide a record of light intensities and discharge products. Another development out of the wire experiments is a high frequency response current shunt which measures voltage drop across the wire. This advanced device replaces the classical shunt technique formerly used in such measurements. It is extremely applicable to high currents, is smaller than the previous device, simple to build and possesses low inductance and high frequency response.

The high intensity light source which may be obtained by exploding wire may prove ideal for space communications and searchlight operations within the atmosphere. Surface temperatures of 5000°C plus the superheated interior would give such a light source excellent visibility and long duration.

Other possible applications are detonation devices for fuzes and solid propellants, fuses for protection of capsulators, and special welding techniques.

20 Technical Sessions Set for IRE Convention

Los Angeles—Top Department of Defense research and development officials will be principal speakers at the IRE 1960 Winter Convention on Military Electronics here, February 3-5. They include James M. Bridges, Director of Electronics, DOD Research and Engineering; Lt. Gen. Arthur G. Trudeau, Chief of Army R&D; and Maj. Gen. O. J. Ritland, Commander of AFBMD.

Bridges will chair the convention's opening keynote session, General Trudeau will speak at the Wednesday luncheon meeting, and General Ritland will be the banquet speaker.

Papers of special interest to be presented in the 20 technical sessions include Project *Mercury* communications, re-entry problems, a portable atomic frequency standard, thin-film ferromagnetic modulators, redundancy, and range safety instrumentation at Vandenberg AFB.

Classified sessions will cover presentations on surveillance, reconnaissance, guidance and control and communications.

Other unclassified sessions will present four papers each on satellite system and subsystems, data handling, re-entry, reconnaissance, instrumentation, reliability, telemetry, guidance and control, communications, ranging and tracking, and components.

The keynote panel session will be devoted to the satellite as a transmission medium for global communications. Members of the panel are Paul Price, ARPA; Dr. John R. Pierce, **Bell Labs;** Dr. Hans Ziegler, Signal Corps R&D Lab; and Brig. Gen. John B. Bestic, AF Deputy Director of Communication Electronics.

North-Seeking Gyro Is Accurate within 5 Seconds

Santa Monica, Calif. — An extremely accurate North-Seeking Gyroscope with an accuracy of better than five seconds of arc is being developed by **Lear, Incorporated.**

The system has been under study, development and fabrication for the Army Ballistic Missile Agency for the past three years. The instrument was jointly developed by two divisions—the **Lear Astronics Division** here, and **Lear Electronic GmbH** in Munich, Germany.

The ±5 seconds of arc accuracy attained by the gyro has been reduced under certain favorable conditions. In a recent series of tests, the rms (root mean square) error was 3.55 seconds. The follow-up servo developed for use with the present gyro is capable of tracking the gyro with an accuracy of ±1 second of arc.

The present North-Seeking Gyro (NSG) was developed specifically as a prime azimuth reference for mobile ballistic missiles. To illustrate the order of accuracy involved: a 5-second azimuth error at launch would cause an off-target impact of about 800 feet over the full range of an ICBM, assuming no errors in the missile guidance system.

Critical azimuth adjustment becomes even more important when dealing with the vast distances of space. A moon probe, for example, could miss its impact point by 1.2 miles for each second of azimuth misalignment at launch.

- **Ten-year development**—Originally

developed in Germany for use in precisely determining true north for underground mine surveying, the device has been considerably refined; it is expected to prove useful in space vehicle applications and rapid all-weather surveys of missile launching sites, in addition to mining operations and geodetic surveying.

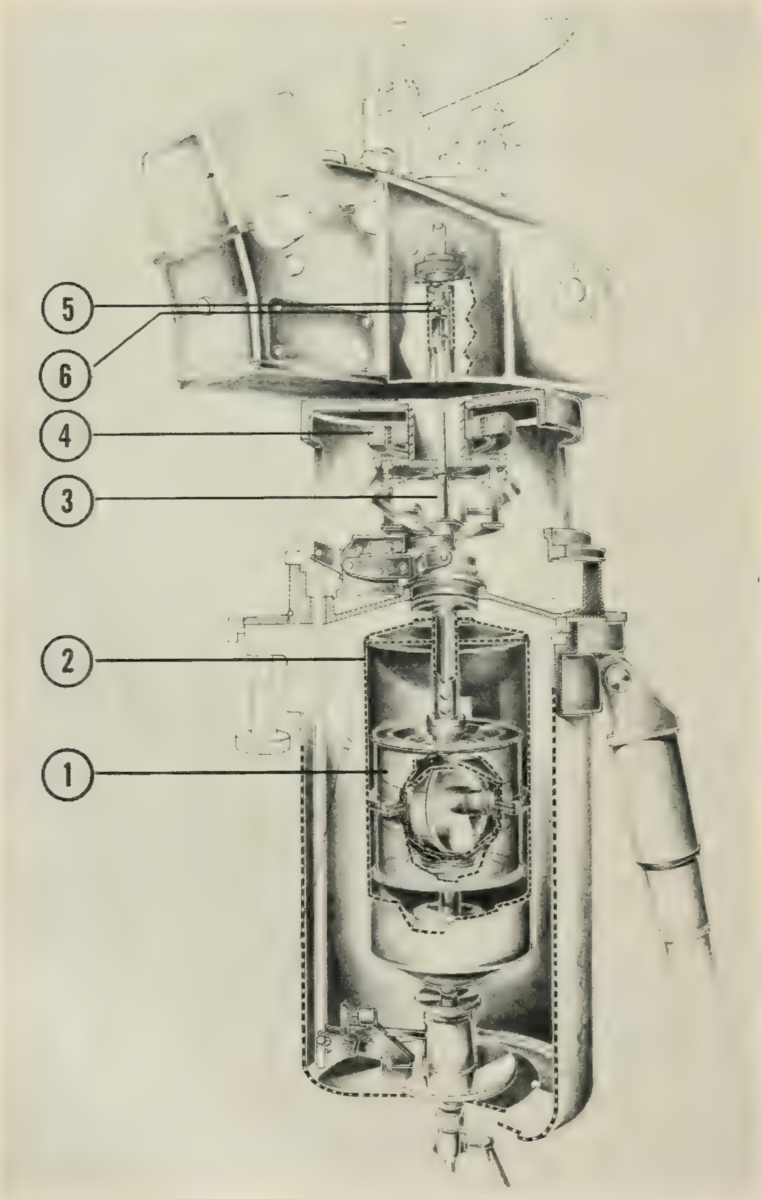
From the original instrument, which had an accuracy of ±1 minute of arc, to the present design took about 10 years of development work.

The underlying physical principle is the tendency of a pendulous gyro, suspended with its spin axis horizontal, to align the latter with the horizontal component of the earth's spin velocity. Consequently, the system locates true, rather than magnetic, north.

• **How it works**—As shown in the schematic diagram, the gyro element is suspended in an inner cylinder (1) filled with helium. This inner cylinder in turn in enclosed by an outer cylinder (2), which serves as structure and bearing support for the rotating inner cylinder. The gyro spin axis is initially roughly aligned with north with a magnetic compass. After the gyro is brought up to speed, it is uncaged by rotating the caging lever. The spin axis of the gyro then tends to align itself with the meridian.

Since the gyro is essentially undamped, it will oscillate around true north—the period of the oscillation being 13.5 minutes. The amplitude will vary, depending upon the position of the gyro at the time of uncaging. Power transfer to the gyro is accomplished by means of thin silver bands (3) whose torsional moments are negligible.

A precision electromechanical servo (4) tracks the oscillating gyro with an accuracy of one second of arc, and rotates the upper band clamp (5) in phase with the gyro, thus eliminating torsion effects of the steel suspension band (6). The volume between the inner and outer cylinders is filled with silicon oil, which partially floats the gyro and reduces the band tension.



SCHEMATIC DIAGRAM of Lear's North-Seeking Gyro (see text above). The basic principle involved enables the system to locate true, rather than magnetic, north.

Flame Sprayer Melts, Deposits Any Material

WESTBURY, N.Y.—**Metallizing Engineering Co. Inc.** has announced a hand metal spraying tool that can melt or vaporize any known material and deposit it on a surface.

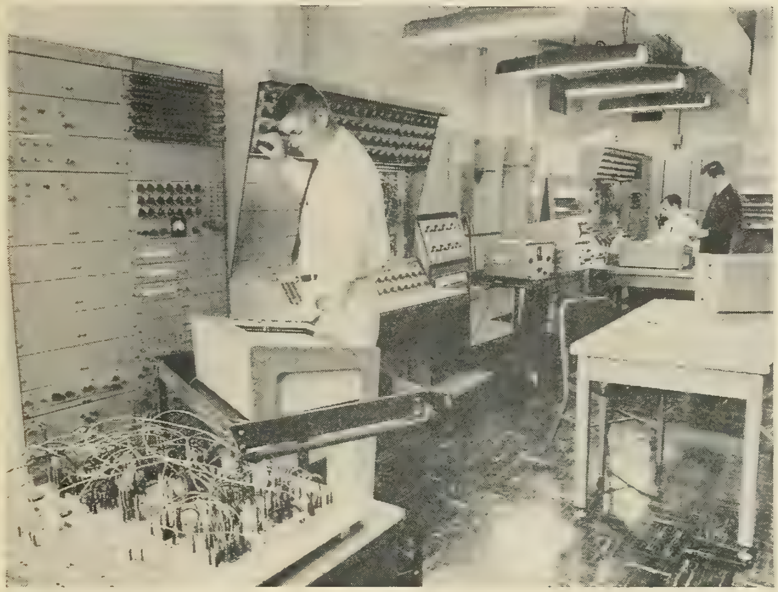
The tool is a plasma flame sprayer that utilizes a technique used hitherto to spray metals or metal oxides on rocket nozzles, nose cones and other equipment subject to extreme thermal conditions, such as crucibles for high-melting-point materials.

The flame sprayer will operate in a vacuum or in any atmosphere. It can operate up to 30,000°F, enough to melt the hardest materials, and spray them on to surfaces. Titanium, for instance, may be sprayed onto softer metal to give it a hard finish.

Physical and metallurgical properties of the coatings obtained are generally superior to conventional flame-sprayed coating, METCO President R. A. Axline reports.

Conventional flame-spraying techniques involve use of chemical fuel, such as oxy-acetylene, to melt materials to be sprayed. The plasma sprayer uses an electric arc to heat a relatively inert gas, such as nitrogen, into the plasma state, or so-called "fourth state of matter," at which it is highly ionized. The material to be sprayed is fed, in the form of rod or powder, into the plasma flame and shot onto the material.

Cost is about $10,000 for a hand sprayer and equipment, which includes a small computer—as big as a man—for equipment control.



Evaluators Save Time, Money

SYRACUSE, N.Y.—A new systems evaluator developed here by the **General Electric Co.'s** Defense Systems Department, is said to shorten electric system development by as much as 25 per cent.

The GEESE (GE Electronic System Evaluator) will enable design engineers to predict if a system will operate at top efficiency even before it goes into production, according to company engineers. The evaluator eliminates the need for costly intermediate hardware by simulating operation early in the development cycle.

GEESE, through the use of analog simulation techniques, can be used to simulate all types of radar and communication systems and to evaluate the effects of electronic countermeasures and mutual interference. It can generate and combine all types of r-f signals to determine the effects of imposed jamming and anti-jamming techniques, eliminating complex and expensive laboratory evaluation equipment.

The primary advantage claimed for the GEESE is its ability to vary system parameters simply and quickly and to record all transient and steady-state conditions with standard oscilloscopes. It includes a time scale up to one million to one so that r-f and i-f carriers can be recorded.

Almost any conceivable signal can be generated on the GEESE. Amplitude-, frequency-, and pulse-modulation techniques have been developed; doppler shift and noise have also been used in systems analysis. Signal frequency, phase, and amplitude can be controlled and their instantaneous effect on system performance observed. Other parameters—signal design, receiver gain, r-f and video, limit levels, detector characteristics, and age time constants—can be varied for investigation of simulated system operation.

The amplitude of return signals varies as a function of time, range, and antenna heading and can also be varied with potentiometer controls. Variations in signal strength are obtained with resolvers and multipliers.

Target size, as well as position, can be controlled. Jamming or interference signals are simulated in type, power, and frequency. All can be varied as functions of position and time.

The GEESE receiver uses an electronic multiplexer as a mixer. Various Filter networks can be used for the r-f and i-f section, their characteristics determined by potentiometer settings.

Programming is accomplished with modular building blocks. This feature, plus the almost unlimited number and variety of inputs and controls available, gives the system flexibility and application limited only by the analog equipment available.

Circle No. 225 on Subscriber Service Card.

Rubber Sleeve Insulators Protect Solid-Fuel Cases

Rubber sleeve insulators manufactured by **The Garlock Packing Company** are being used to insulate the outer case from the solid fuel of rockets and missiles. This insulation was used in the *Pioneer* moon rocket launched last fall.

The sleeve is made of a rubber compound developed by the Naval Research Laboratory. Without this insulation the intense heat and velocity of the propellant would burn through the motor casing, causing complete failure of the missile. The insulator is currently being used in the Navy's submarine-launched *Polaris* missile. Garlock has also developed similar insulators for the third-stage *Vanguard, Super Vanguard, Terrier, Super Tarter, Talos* Booster, the Air Force's *Minuteman* and certain outer space probe vehicles.

The company has also developed a filament-wound chamber to encase the insulator and propellant. The chamber must be able to withstand the tremendous pressures of the "controlled explosion" of the rocket engine.

Circle No. 226 on Subscriber Service Card.

Aluminum Alloy Patented

Navan Products Inc., invention marketing subsidiary of **North American Aviation,** has patented an aluminum alloy it says is used in the majority of aluminum castings in liquid-rocket engines that have powered the nation's successful major missiles.

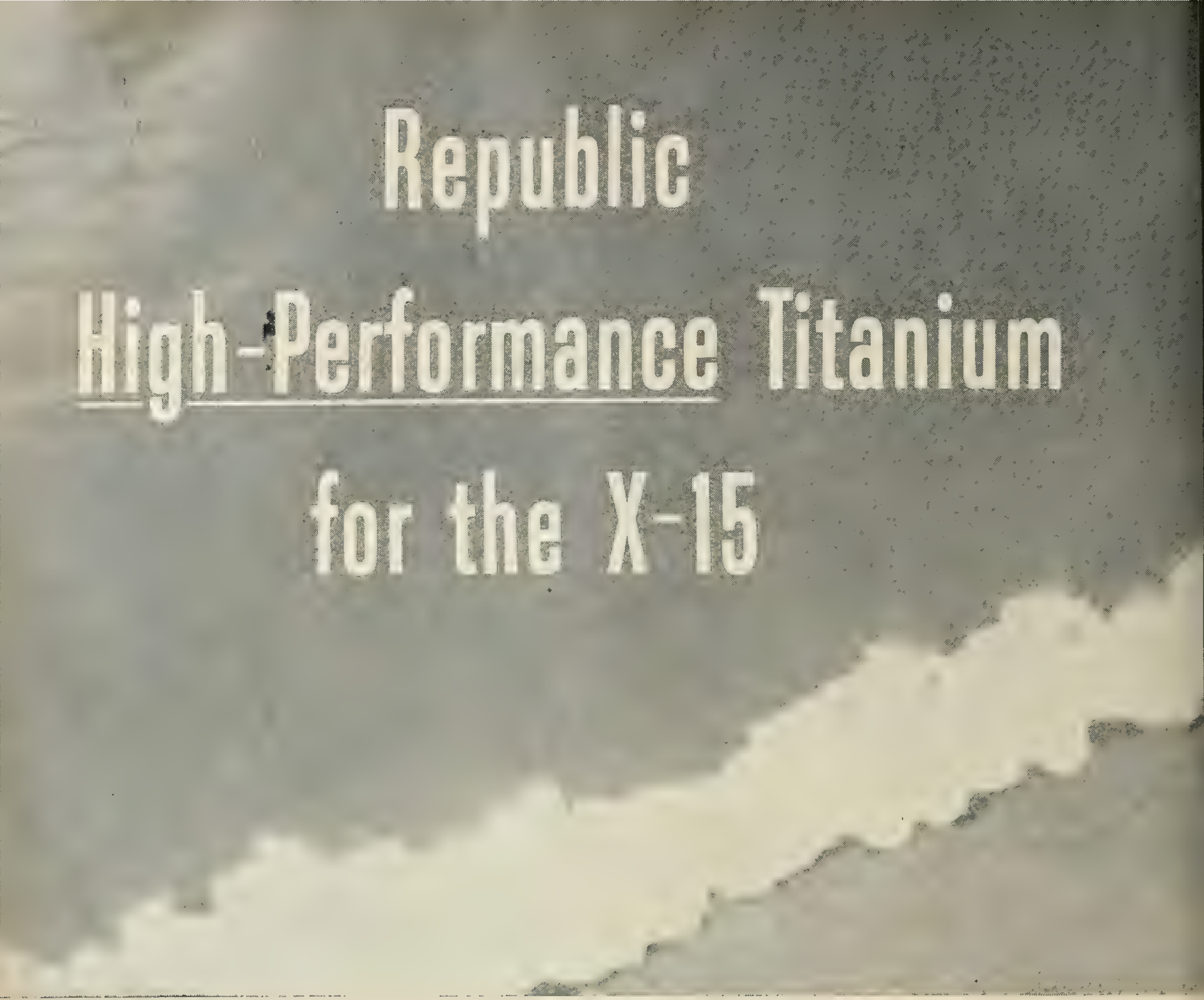
The alloy, called "Tens-50," contains about 8% silicon, 0.5% magnesium, 0.2% beryllium and 0.15% titanium.

Circle No. 227 on Subscriber Service Card.

Gamma Spectrometer Unit Eliminates 'Dark Current'

A new gamma spectrometer system designed to eliminate the "dark current" defect common to conventional systems is offered by **Nuclear Measurements Corp.** It is said to offer better resolution over a wider range, and to provide greater precision in gamma spectroscopy than any other equipment now available.

Unlike conventional "sliding window" systems; the new system is a "sliding pulse" type, employing photomultiplier tubes, transistors and sensitive discriminators. The pulse is brought



Republic High-Performance Titanium for the X-15

In a number of highly stressed components subject to extreme high and low temperature fluctuations, *high-performance* titanium in the X-15 Research Vehicle will help take man higher and faster than he has ever been before.

Republic Steel—a leading supplier of titanium, and the nation's largest producer of stainless and alloy steels—is supplying North American Aviation with Type 110A titanium for internal structures on the X-15 project.

Let us help you utilize *high-performance* metals to increase strength, resist heat, or trim weight. Write Republic Steel, Dept. MR-8591, 1441 Republic Building, Cleveland 1, Ohio.
Please indicate if you would like a titanium metallurgist to call.

REPUBLIC STEEL *Where Steels are*

FIRST POWERED FLIGHT of the North American X-15 came on September 21, 1959, over Edwards AFB. Carrying a full load of fuel (note frost from liquid oxygen at top and bottom of fuselage), the X-15 flew under power for 3.5 minutes at speeds in excess of Mach 2.

REPUBLIC STAINLESS STEEL is used in leading edges of the Convair 880's vertical fin and horizontal stabilizer where anti-icing is accomplished through electrical heating of the metal. Use of Republic ENDURO® Stainless Steel increases strength and heat-resistance, permits thinner, lighter gages. Types 301 and 302 are readily formed into desired shapes by cold forming, drawing, and bending operations.

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE HS6460

is ideal for sinterings of highly stressed components. Provides minimum tensile strength of 60,000 psi at 6.4 density as sintered . . . 100,000 psi after heat treatment. Maximum of .004% shrinkage from die size at 6.4 density. Available in quantities up to and including 12 tons or multiples. Can be used with existing operating equipment.

REPUBLIC VACUUM-MELTED ALLOYS heat treated to tensile strength levels of 270,000 to 300,000 psi are produced in fifteen thousand-pound heats for missiles such as the Minuteman. Vacuum arc process minimizes segregation and center porosity. Nonmetallic inclusions are reduced in number and size. Transverse ductility at high strength levels is also greatly improved.

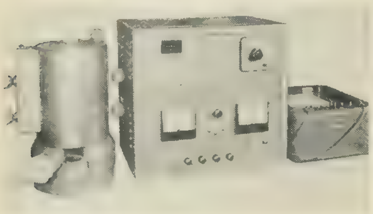
Made to Meet the Challenge of Acceleration

REPUBLIC STEEL ®

Circle No. 8 on Subscriber Service Card.

to the window rather than the window to the pulse.

Designated Model GSS-1, the system is built around two basic components—a combination linear count ratemeter and all-transistorized spectrometer circuit, and a probe assembly including spectrometer grade photomultiplier tube with 2" x 2" NaI scintillation crystal, coupled directly to an all-transistorized amplifier. Integrated with these are other units—a universal shield with sample slides, a decade type slave scaler, and a graphic recorder.



Circle No. 228 on Subscriber Service Card.

Low-cost Modified Epoxy Adhesive Is 100% Reactive

A 100% reactive, room-temperature curing epoxy adhesive, Bondmaster M685, has been formulated by the **Rubber and Asbestos Corp.**

In 6-drum lots, the mixed cost of M685 and its hardener is about $7.75 per gal. The modified epoxy adhesive is a free-flowing liquid (3000 to 7000 cps). Mixed weight, with hardener, is 9.6 lbs to the gallon. Pot life with Hardener CH-22 is 60-90 minutes; with Hardener CH-34 approximately 45 minutes, depending on the size of the container used.

At room temperature, the bonded assembly can be handled in 6-8 hours and develops 85% maximum strength in 14-24 hours. The formulation may be heat-cured in 10 minutes at 250°F.

Circle No. 229 on Subscriber Service Card.

Bonding Permits Hermetic Seals in Microwave Systems

Development of a group of modified fluorocarbons called Raibond which makes possible a stronger, more elastic bond between metal and plastic components of microwave transmission systems has been announced by **Radiation Applications, Inc.**

The product is said to permit the use of newly developed adhesives, with substantially increased low-temperature flexibility, in waveguide equipment. For this reason, the development may have a highly favorable impact on the performance of radio and radar devices in sub-freezing regions.

Raibond-modified fluorocarbons are employed as plugs in microwave guide "plumbing" systems designed to keep out water and dirt and to keep in either hydraulic fluid or pressurized gases. The fluorocarbons to which it has been applied are Kel-F and Teflon, produced, respectively, by **Minnesota Mining and Manufacturing Co.** and **E. I. DuPont de Nemours & Co., Inc.**

RAI engineers discovered that Teflon and Kel-F could be successfully bonded to metals with room temperature vulcanizing (RTV) silicone rubbers in place of the epoxies formerly used. The resulting bonds are flexible and pressure tight. In addition, Raibond retains all of the electrical characteristics of the original Teflon or Kel-F. This results in a higher efficiency of microwave transmission—marked by plumbing with a lower loss factor—than can be obtained with conventionally bonded Teflon.

In the past, problems arose with epoxy adhesives at extremely low temperatures (of the order of –100°F) because of the difference in thermal expansion and contraction between the plastics and metal of the waveguide.

Circle No. 230 on Subscriber Service Card.

Spin Stabilization Aids *Polaris*

A pneumatic spin stabilization system weighing less than three pounds has been developed by the **Solar Aircraft Co.** for use in controlling reentry bodies of test vehicles in the development program for the U.S. Navy's *Polaris* ballistics missile.

The system was manufactured by Solar to specifications of **Lockheed Missiles and Space Division.** Lockheed is manager of the *Polaris* missile system.

A high pressure spin control system consists of a sealed tank about eight inches long charged with nitrogen and controlled by an explosive-actuated valve.

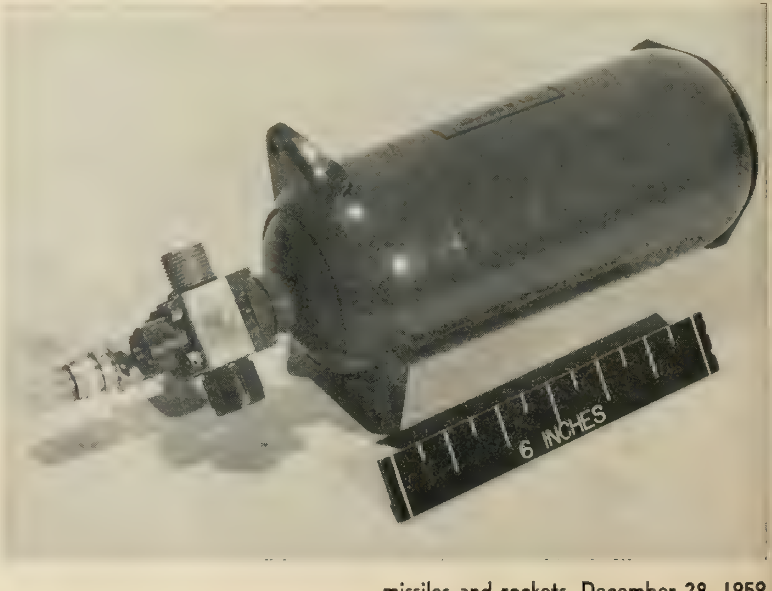
In operation, the actuator is fired by an electrical impulse. The resulting gas energy unloads a piston-supported metal diaphragm. The resulting gas energy unloads a piston-supported metal diaphragm. The internal nitrogen gas pressure then ruptures the diaphragm and the gas is discharged through two opposed valve openings at 3000 psia.

This emitted gas, from several of these small systems, provides stabilization for the missile's re-entry body. Solar engineers have incorporated an over-pressure thermal relief device into the system to prevent premature firing.

By hermetically sealing the nitrogen gas, the system is insensitive to environmental storage conditions with a minimum storage life of five years in the charged condition.

Burst tests of the system's tank, made of alloy steel with walls .050 inches thick, by Solar and an outside testing laboratory have consistently recorded a hoop bursting strength of a minimum of 280,000 psi and a maximum of 307,000 psi.

Circle No. 231 on Subscriber Service Card.



New Material Features Low Ablation Loss

A material with high heat-resistant properties has been developed by the **Cordo Chemical Corp.** Called Resin Bonded Quartz Sheet, it is a combination of reinforced plastics and ceramics.

Both of these materials have been used with varying success in the rocket and missiles field, but neither alone is the complete answer to the extremes of temperature encountered in these applications.

Resin Bonded Quartz Sheet has advantages over either plastics or ceramics alone. Aside from the obvious fact that it out performs other materials in current use, it is markedly lower in price and handles as well, if not better than such materials.

Finely divided particles of fused quartz are bonded together with already proven high temperature-resistant Cordo Pyropreg resin. A small percentage of glass or other fibers is included to give the resultant sheet good handling properties. The sheet assumes the black color of the Pyropreg resin and looks very much like a normal pre-impregnated fabric except that there is, of course, no cloth weave to be seen.

The Cordo Chemical Corporation recommends using this material as a facing on a laminate of standard Pyropreg reinforced plastic. Resin Bonded Quartz Sheet is not a structural material, and in the cured form has physical properties comparable to the resin itself. Its strength is ample for shielding properties but contributes little to the over-all structure.

The special property of low ablation loss under extreme conditions is attributable in large part to the use of quartz. The fused quartz particles used in Resin Bonded Quartz Sheet have an extremely low coefficient of thermal expansion. The melting point of this fused quartz is in excess of 3100°F., and the resultant liquid is extremely viscous so that it is not washed off the surface but tends to act as an insulator for the material which is not yet melted.

The low ablation loss feature is apparent. Five panels have been tested in the 5500°F blast of an O-H rocket motor for sixty seconds. Panels number one, three, and the unnumbered panel were dropped in cold water within a matter of seconds after the rocket motor was cut off. The panels which show cracks were not damaged during the test. This was mechanical damage in shipping the exposed panels.

Resin Bonded Quartz Sheet is avail-

propulsion engineering . . .

By JAY HOLMES

Nuclear propulsion and APU proposals . . .

are drawing bigger and bigger responses. Two dozen companies—many more than expected—attended a briefing this month on an Air Research & Development Command contract for design studies and development of a 300 kilowatt nuclear mechanical power system suitable for use in a space vehicle.

Such a power source could function as an auxiliary power system or deliver a service load drawn by an electrical propulsion device—such as ion or plasma. However, 300 KW would provide only a few pounds of thrust, even at top efficiency.

The nuclear industry is pleased with the development because it expects progress on electrical propulsion to pull far ahead of power sources available. The ARDC source will take at least five years to develop. Ion propulsion devices could be ready in two years.

Development cost of $50 million . . .

is a figure bandied about in industry. ARDC won't say, of course. Only a small fraction of the total is involved in the design study, the first phase. Bids on the design study, expected to take about a year, are due Feb. 1. With additional "examining" time needed for circulation of the second round of development phase bids, it is clear that work in earnest may not begin for almost two years.

ARDC, associated with the Atomic Energy Commission, is calling for a reactor power source based on rotating machinery. Thermionic conversion is out for the present. The Aeronautical Accessories Laboratory at Wright Air Development Center, Dayton, says the device may not be used in an actual vehicle. The prime objective of the work is to advance the state of technology.

Solid motors weighing 5-10,000 lbs. . . .

will be produced at the Kansas Ordnance Plant at Parsons by **Grand Central** if the Army gives the go-ahead. Architect-engineering studies, now in progress, will be completed late in 1960.

No specific projects are scheduled for Parsons; the Army sees the plant as a possible backup, in case of production slippage elsewhere. It will have a limited capacity but will be capable of expansion.

Too-detailed specifications . . .

are causing annoyance in several shops. Case makers fail to see why welds in solid rockets should be dressed down, when machining may introduce weaknesses. Others are irked at the need for machining case interiors—when the surface is immediately roughened by application of plastic inhibitor, painted on with a brush before the grain is cast.

Metal suppliers wonder why aeronautical specifications are put on some materials that never will get higher than the tailgate of a truck. On the other side, fabricators complain of poor quality metal furnished when they demand highest purity. Vendors guarantee that chemical impurities are below a specified level, but they neglect to mention one compound—DIRT.

Industry is giving horselaugh . . .

to an inexperienced casemaker who took ideas that an experienced company had presented on the first feasibility go-round, incorporated them in his production plan and filed the lowest bid. When he couldn't produce, he went running to originator for help. Result: the experienced company made a small profit and the chiseler lost his shirt.

Other chuckles are generated by a West Coast man who proposes wood-burning rockets. He would save money on the insulation too—by using wadded-up old newspapers.

able in thickness of from 10 to 20 mils and is 36" wide. Special thicknesses and widths can be special ordered. Roll length is normally 30 to 40 yards. The material can also be supplied in a diced form. It may be ordered from Cordo Molding Products, Inc., 230 Park Avenue, New York, New York, and their nation-wide representatives.

One of the most interesting features of this material is its price. Resin Bonded Quartz Sheet is actually priced lower than standard pre-impregnated glass fabric, which is several times lower than high silica materials such as Refrasil, and many, many times lower than pure quartz fabric reinforced materials.

Circle No. 232 on Subscriber Service Card.

New Literature

TRANSISTORS. A 16-page Brochure available from the **General Transistor Corp.,** describes its complete line of PNP and NPN transistors most widely used by original equipment manufacturers. Complete specifications are provided; characteristics given are minimum standards against which GT Transistors are 100% tested. A GT Transistor applications chart is included. Sections are devoted to: audio transistors (for audio amplifier and low speed computers); computer transistors (PNP and NPN for low to medium speed AC amplifier and medium current DC switching); high current computer transistors; photo transistors; bilateral transistors (NPN for core and drum memory addressing and chopper applications); drift transistors (PNP for DC computer applications); high voltage transistors (PNP and NPN for driving Nixie and Neon tubes); and silicon alloy junction transistors (PNP and NPN).

Circle No. 200 on Subscriber Service Card,

GYROS. A 62-page technical manual for subminiature rate gyroscopes has been prepared and published by **Sanders Associates, Inc.** The manual contains the basic principles of operation of this subminiature type gyro and covers the operating characteristics, standard types available, transformer pickoff, and use and design of packages of one-, two-, and three-axis sensors for rate and acceleration.

Circle No. 201 on Subscriber Service Card.

FASTENERS. An illustrated engineering data catalogue describing bolts, nuts, screws, dowels, etc., which can be used at elevated temperatures has been published by the **Mercury Air Parts Co.** Fabricated to AMS 5735 for 1300 degree to 1800 degree applications. Non magnetic and corrosion resistant.

Circle No. 202 on Subscriber Service Card.

west coast industry . . .

By FRANK G. McGUIRE

Distribution of trade union members throughout California has been determined by Irving Bernstein, associate director of UCLA's Institute of Industrial Relations. The state's past conception of San Francisco as a "union town" and Los Angeles as an "open-shop city" must be re-evaluated in light of actual distribution of unionists, says Bernstein. Trade union membership in the Los Angeles-Long Beach area is between 200,000 and 250,000 more than in the nine counties of the San Francisco Bay region.

Despite this shift from one large city to another, the UCLA study shows that unions have made their biggest gains in smaller urban communities, not in the big cities. This trend is most noticeable in southern California. Between 1954 and 1957, unions made their largest increase, percentagewise, in Imperial, Riverside and San Bernardino counties, followed by Santa Barbara-Ventura, Sacramento Valley, San Diego County, and Los Angeles-Long Beach.

San Diego may soon become the state's third major center of trade union strength, if its present rate of growth continues. Leadership in at least one respect has been retained by San Francisco-Oakland, because half of their total work force belongs to unions—a higher percentage than any other California city. The general decline of the Bay City as the state's union stronghold has been attributed to the decline of the maritime unions and the fast growth of such other organizations as the Teamsters.

United Research Corporation . . .

is moving into solid-propellant rocketry at a rapid pace. The briefing held November 10 at Edwards AFB on a large solid-propellant booster included **URC** in such company as **Thiokol, Rocketdyne, Aerojet, Grand Central, Hercules Powder,** and **Atlantic Research.** The recently-formed subsidiary of **United Aircraft Corp.** is expected to contribute mostly research to any such program, pending completion of its plants, but even this capability represents very rapid growth.

Convair will start construction . . .

of its $4-million Astronautics warehouse building, following failure of an opposing petition to block the project. The building will be used for offices (about 1/3) and storage of components. Completion is expected in the fall of 1960. The construction site is adjacent to the **Convair (Astronautics)** plant on Kearney Mesa.

Metal Control Laboratories . . .

has purchased **Pacific Testing Laboratories, Inc.** MCL, a Huntington Park, Calif., firm, will move the equipment and personnel of PTL from the Van Nuys location. Both firms specialize in testing and research.

Astral Electronics Inc. . . .

has received a $113,446 contract from AF for chemical, biological and radiological defense training sets. The contract is apparently the first of its type to be awarded by a government agency, and reflects a growing interest in the field.

University of California will research . . .

the process of mass transfer—the means by which the molecules of one chemical spread themselves out among the molecules of another—in order to determine its mechanics. The $125,200 grant will benefit rocket fuel development, and will aid in predicting how two materials will interact under certain conditions.

More politics than security . . .

pervades some aspects of the missile program. For example, the configuration of the *Nike-Zeus* is not classified, but is marked "for official use only" and kept from public view. The argument is that the configuration may soon undergo a complete change, and make the present bird a misleading representative of the program.

FROM LAGRANGIAN TO LIFT-OFF

Sometimes forgotten during the thundering ascent of a space probe rocket are months of meticulous analysis, engineering and planning. The staff of Space Technology Laboratories is now engaged in a broad program of space research for the Air Force, the National Aeronautics and Space Administration and the Advanced Research Projects Agency under the direction of the Air Force Ballistic Missile Division. For space probe projects STL provides the total concept approach, including preliminary analysis, sub-system development, design, fabrication, testing, launch operations and data evaluation. The total task requires subtle original analysis in many fields as well as sound technical management.

The STL technical staff brings to this space research the talents which have provided system engineering and technical direction since 1954 to the Air Force Ballistic Missile Program. Major missile systems currently in this program are Atlas, Titan, Thor and Minuteman.

The scope of STL's responsibilities offers creative engineers, physicists and mathematicians unusual opportunities to see their ideas tested in working hardware. Inquiries are invited regarding staff openings in the areas of Advanced Systems Analysis, Rocket Propulsion, Space Flight Mechanics, Dynamics, Structural Analysis, and Aerodynamics.

Space Technology Laboratories, Inc.
P. O. Box 95004, Los Angeles 45, California

$$\mathcal{L} = \frac{m}{2}\left(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\sin^2\theta\,\dot{\phi}^2\right) + \frac{GMm}{r}$$

Missiles and Rockets Editorial Index

Readers are invited to save the following six-month index covering M/R issues of July 6, 1959 through Dec. 28, 1959. This index is a reference guide to major news and technical articles published in M/R during the last half of the year.

ASTRIONICS

Antennas

ANTENNAS: THERE'S A LIMIT IN SIZE; What's needed is the ability to manufacture dishes and maintain them in an exposed environment to the close tolerances required, by Hal Gettings, M/R Associate Editor, 8/10/59, p. 18.

Automatic Checkout

UNIVERSAL CHECKOUT CENTER IS URGED TO MATCH WEAPON ADVANCES; Packard Bell, with experience in Polaris, Thor and Falcon programs, believes the concept will reduce inventories and personnel and enhance portability, 10/5/59, p. 23.

A CLOSE-UP OF TWO AUTOMATIC CHECKOUT SYSTEMS; Curtiss-Wright's DEMON and Nortronics' NORSCAN are fully transistorized, modularly constructed and completely self-checking, by Charles D. LaFond, M/R Associate Editor, 7/6/59, p. 33.

Communications

DEVICES COULD HANDLE 300 MILLION WORDS, SEC; 12/7/59, p. 26.

EXPLORER VI MAY SOLVE PUZZLE OF REPETITIOUS RADIO SIGNALS; 11/9/59, p. 24.

PROMISE OF NEW 'DECISION THRESHOLD COMPUTER'; Simple device performs well in NATO scatter stations and is expected to find application in telemetry, especially over long distances, by Charles D. LaFond, M/R Associate Editor, 8/24/59, p. 18.

Components

EYELETS VS. PLATED-THRU HOLES IN PRINTED CIRCUITRY; A report on a comprehensive test in which all located failures were in eyeletted phenolic boards, by Barnard C. Alzua, Jr., 7/27/59, p. 37.

Control Systems

RCA SYSTEM DESIGNED TO RELIEVE INTERFERENCE TROUBLES; 8/31/59, p. 32.

PROMISE OF A NEW 'DECISION THRESHOLD COMPUTER'; Simple device performs well in NATO scatter stations and is expected to find application in telemetry, especially over long distances, by Charles D. LaFond, M/R Associate Editor, 8/24/59, p. 18.

Data Processing

DEVICES COULD HANDLE 300 MILLION WORDS/SEC; 12/7/59, p. 26.

SAGE GUIDES INTERCEPTOR MISSILES; An exclusive account of a computer's role in meeting air attack, by Lawrence R. Jeffery, 9/21/59, p. 56.

Data Recording

TINY RECORDER SURVIVES MISSILE FLIGHT, DUNKING; Ampex unit performs perfectly when retrieved after flight in AF missile nose cone and nine days in the Atlantic, 11/30/59, p. 31.

DATA HANDLING SYSTEM MAY BOOST USE OF DIGITAL TAPE; This 100-lb. Datalab recorder with total capacity of 2.4 billion bits is touted as having great potential for space exploration, 10/5/59, p. 19.

VIDEOTAPE SUCCESSFULLY USED TO RECORD RADAR SIGNALS; Army's Signal Missile Support Agency finds great advantage in immediate playback capability for trajectory evaluation, 9/28/59, p. 24.

MAGNETIC TAPE RECORDING SALES BOOMING; This year should see 700,000 units sold but most promising future applications will be in astronautics for photo-reconnaissance, by Robinette E. McCabe, 8/3/59, p. 34.

Electronic Cooling

IR INDUSTRY IS SOLVING ITS COOLING PROBLEM; IR-Detector cells are behind the state-of-the-art of cells, but R&D is closing the gap with better hardware and advanced methods, by Charles D. LaFond, M/R Associate Editor, 11/2/59, p. 16.

HUGHES RESEARCH REVEALS ADVANCES IN INFRARED DETECTION; Shielding technique doubles IR search and tracking range; cooling methods treble detectivity of IR cells, 9/28/59, p. 19.

NEW TECHNIQUES AID ELECTRONICS COOLING; Basic methods of heat dissipation in components are the same but the applications can vary. Here are principal methods, by Hal Gettings and Charles D. LaFond, M/R Associate Editors, 8/3/59, p. 38.

ELECTRONICS COOLING — MULTIMILLION-DOLLAR STEPCHILD; The demand for cooling units is growing. An M/R staff survey shows how the challenge is being met. First of two stories, by Hal Gettings and Charles D. LaFond, M/R Associate Editors, 7/27/59, p. 34.

Energy Conversion

Isp MAY BE UPPED BY WIRE EXPLOSIONS; Company believes this propulsion can provide more power than most proposed electrical systems offer; other uses seen in communication, attitude correction, 12/28/59, p. 20.

ENERGY CONVERSION GROWS IN IMPORTANCE; New stress on space and potential commercial uses gives impetus to search for more and better ways to convert energy directly to usable electricity, by Hal Gettings, M/R Associate Editor, 12/7/59, p. 22.

SOLAR ENERGY DEVICE CAN PRODUCE AC OR DC POWER; 12/7/59, p. 39.

WORLD'S BIGGEST SOLAR ENERGY CONVERTER USED TO OPEN HOFFMAN SEMICONDUCTOR PLANT; 11/30/59, p. 25.

MISSILE APU MAKER DENIES BATTERIES ARE ALWAYS BEST; Sundstrand Co.'s rebuttal to report by Frank Cook Co. charges among other things that Cook report "compares apples and oranges," 11/2/59, p. 18.

BATTERY MAKER'S REPORT CLOBBERS HOT-GAS APU's; by Charles D. LaFond, M/R Associate Editor, 8/31/59, p. 33.

BATTERIES RETAIN MAJOR MISSILE POWER ROLE; Survey shows electrochemical batteries are desirable auxiliary power sources for many uses; sales expected to grow ten-fold, by Charles D. LaFond, M/R Associate Editor, 8/24/59, p. 15.

APU'S—AN OFT-NEGLECTED $25 MILLION BUSINESS; Report shows that gas-turbines are first choice for missile auxiliary power units, with batteries close behind; exotic sources still in the future; crash programs make complications, by Hal Gettings, M/R Associate Editor, 8/17/59, p. 31.

PUSHING THE SEARCH FOR SPACE VEHICLE POWER; Government and industry strive to find sources of electrical power that will permit prolonged space missions, by Paul Means, M/R Associate Editor, 7/27/59, p. 22.

Fuzing and Arming

THE REMARKABLE RELIABILITY OF FUZING AND ARMING; An outline of the accomplishments and tricky requirements in a secrecy-shrouded and largely government-controlled field, by Hal Gettings, M/R Associate Editor, 7/6/59, p. 30.

Guidance

NERVE CELL RESEARCH URGED FOR 'DECISION-MAKING' GUIDANCE; Armed Forces Chemical Association also hears of need for work in dielectric behavior in space, by John Judge, M/R Associate Editor, 9/21/59, p. 85.

SOVIET MOON HIT DEMONSTRATES GUIDANCE PROWESS; Achievement on eve of Khrushchev's visit, predicted in Aug. 17 M/R, indicates high degree of accuracy in delivering ICBM's, by C. Paul Means, M/R Associate Editor, 9/21/59, p. 108.

Gyros

NORTH SEEKING GYRO IS ACCURATE WITHIN 5 SECONDS; 12/28/59, p. 23.

TODAY'S GYROS WON'T MEET TOMORROW'S NEEDS; Recent advances keep missile gyros up to present demands, but significant progress is needed for operational missiles and spacecraft, by Hal Gettings, M/R Associate Editor, 9/28/59, p. 15.

Industry & Markets

COMPUTER SIMULATION OF LAB TESTS MAY SAVE TIME, MONEY; Experiments during design phase indicate considerable economies are possible along with improved reliability; C-E-I-R's approach is described, by Charles D. LaFond, M/R Associate Editor, 12/21/59, p. 19.

ARNOUX DEVELOPING MAGNETOMETER FOR MISSILES AND SMALL SPACE VEHICLES; Arnoux Corp. has in prototype stage a device which should meet the low weight, small size and other demands of missiles and small space vehicles, 12/14/59, p. 25.

ENERGY CONVERSION GROWS IN IMPORTANCE; New stress on space and potential commercial uses gives impetus to search for more and better ways to convert energy directly to usable electricity, by Hal Gettings, M/R Associate Editor, 12/7/59, p. 22.

THE EXPLODING SEMICONDUCTOR INDUSTRY; It is already a half-billion-dollar-a-year business, and the total may double in five years unless imports hit the defense market, by Charles D. LaFond, 11/30/59, p. 23.

IR INDUSTRY IS SOLVING ITS COOLING PROBLEM; IR-Detector cells are behind the state-of-the art of cells, but R&D is closing the gap with better hardware and advanced methods, by Charles D. LaFond, M/R Associate Editor, 11/2/59, p. 16.

INFRARED INDUSTRY—BILLION-DOLLAR MARKET?; Opinions differ on sales potential of the complex field, but all agree that it has only been tapped; expansion rate depends on research breakthroughs, product development, by Charles D. LaFond, M/R Associate Editor, 10/26/59, p. 25.

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RESOLUTION IN ELECTROLYTIC MACHINING; Anocut engineers develop cavity sink device to meet metal working challenge of Space Age. A report on this and other recent advances, by John F. Judge, M/R Associate Editor, 11/2/59, p. 29.

METHOD FOUND FOR STRUCTURAL MOLYBDENUM WELDING; Finn Aeronautical Division achieves unheard-of ductility and arouses enthusiasm in industry and government, by John F. Judge, M/R Associate Editor, 10/26/59, p. 40.

BREAKTHROUGH IN HEAT TREAT PROMISES HUGE STRENGTH GAINS; Barrett process gives ultimate metal tensile strength 10% to 60% higher with improved ductility; company expects one-million psi in 18 months, by Frank G. McGuire, 9/28/59, p. 10.

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REYNOLDS NEW ALUMINUM BACK-UP FOR ALUMINUM WELDING; 7/20/59, p. 107.

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MATERIALS WILL HAVE TO OUTDO THEMSELVES; by Dr. George J. Mills, 11/23/59, p. 27.

MISSILE 'INNARDS' MUST TAKE SPACE RIGORS; by Frank McGinnis, 11/23/59, p. 26.

NO MAGIC MATERIALS IN SIGHT; by John L. McDaniel, 11/23/59, p. 31.

PUSHING UP I_{sp} BRINGS FRESH PROBLEMS; by Dr. Morris A. Steinberg, 11/23/59, p. 28.

ROCKETS MUST BE LIGHTER, MORE RELIABLE; by L. L. Gilbert, 11/23/59, p. 21.

STRUCTURAL MATERIALS FACE TOUGH DEMANDS; by A. A. Watts, 11/23/59, p. 19.

THE GROWING ROLE OF MATERIALS ENGINEER; by N. J. Hoffman and D. E. Roda, 11/23/59, p. 22.

NBS PRESSES RESEARCH ON DIELECTRICS; A broad study, partly funded by the Pentagon is aimed at obtaining better measurements and materials, 10/19/59, p. 37.

EMERSON'S PROLIFIC E&A DIVISION; Company compiles an enviable record in missile work and comes up with startling developments for the future while bucking "decentralization" trend, by Charles D. LaFond, M/R Associate Editor, 8/31/59, p. 28.

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AID FROM SILICONE RUBBERS; by Robert Treat Jr., 11/23/59, p. 48.

DEMAND GROWS FOR ASTROLITE; by W. E. Benke, 11/23/59, p. 48.

FILAMENT WINDING FOR CASES; by Richard E. Young, 11/23/59, p. 49.

MORE AND VARIED USES SEEN; by John H. Lux, 11/23/59, p. 46.

NEW IDEAL FOR THERMAL BARRIER; by J. C. Siegle and P. H. Settlage, 11/23/59, p. 46.

OLD ITEMS FIND SPACE USES; by F. William Jahns, Jr., 11/23/59, p. 48.

PHENOLICS GAIN IN MISSILE USES; by Minert E. Hull, 11/23/59, p. 51.

RE-ENTRY VEHICLES USE ABLATION PLASTICS; by L. R. McCreight, 11/23/59, p. 43.

STRENGTH LEVELS TO DOUBLE; by Howard Meinke, 11/23/59, p. 52.

VERSATILE LAMINATED PLASTICS; by Dr. Carlisle M. Thacker, 11/23/59, p. 49.

TITANIUM, PLASTICS GAIN IN ROCKET CASES; These materials may someday form boosters and second stages, although steel is still tops now because of its low cost and familiarity, by Jay Holmes, M/R Associate Editor, 10/12/59, p. 29.

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FIBER GLASS TOUGHENED TEFLON; by Titeflex, Inc., 11/23/59, p. 52.

SWAGE FITTED TEFLON TUBES; by R. C. Ramé, 11/23/59, p. 52.

MISSILES, SATELLITES AND RESEARCH VEHICLES

SECOND EDITION OF M/R ASTROLOG; Latest status report on all U.S. missiles, rockets and space vehicles, plus a new listing of all satellites, U.S. and Russian, now in orbit by M/R Staff, 11/9/59, p. 25.

FIRST EDITION OF M/R ASTROLOG; For the reader's convenience, an easy-reference status report on all space vehicles and missiles, by M/R Staff, 9/7/59, p. 25.

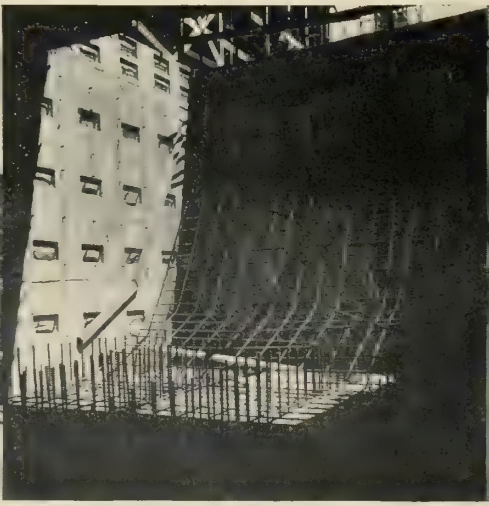
ANNUAL MISSILE ENCYCLOPEDIA; A comprehensive illustrated listing of U.S., Allied and Soviet missiles, by M/R Staff, 7/20/59, p. 137.

Missiles

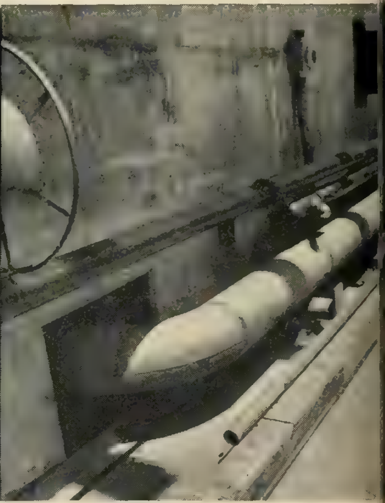
THE AIR FORCE REAPPRAISES THE TITAN PROGRAM; The Ballistic Missile Division reportedly has concluded the missile is basically sound and has place in defense plans; upshot may be thorough congressional investigation of entire ICBM picture, by William J. Coughlin, M/R Los Angeles Bureau Chief, 12/21/59, p. 43.

Somewhere east of Laramie, on one of Wyoming's plains, you'll find the strangest government housing project ever built. Six concrete and steel buildings are being constructed to house Atlas missiles. The site is one of the operational intercontinental missile bases to be operated by the Strategic Air Command. This base is being constructed on the surface. Follow-on bases will burrow deep into the earth. In all these systems, the Air Force puts much emphasis into ground support equipment. Virtually all of the material can be purchased from one firm — United States Steel. Whether it's carbon

The U. S. Army Corps of Engineers is constructing this operational intercontinental missile base in Wyoming. In front of the partially completed Launch and Service Buildings are Col. Sidney T. Martin, in charge of construction, and Maurice K. Graber, a construction engineer for the Corps.



This is the inside of the blast pit of one of the launcher buildings. In all six of these buildings there are 1,040 tons of structural steel, 1,950 tons of reinforcing steel, over 48,000 tons of concrete aggregate, blocks and cement, and 8,040 tons of mechanical steel items.



Fuel lines and process piping are Stainless Ste and operate at pressures up to 15,000 psi. The pipes a kept almost surgically clean to prevent contaminati of fuel and subsequent malfunction. Vapor degreasi and chemical cleaning processes are used on the pipe

steel, high-strength low-alloy steel, ultra high-strength alloy steels, Stainless Steel, steel fence, electrical cable, cement or wire rope, United States Steel maintains the technical services to assist in solving any problem on materials for ground support. When a ground support program goes to the drawing board, consult with

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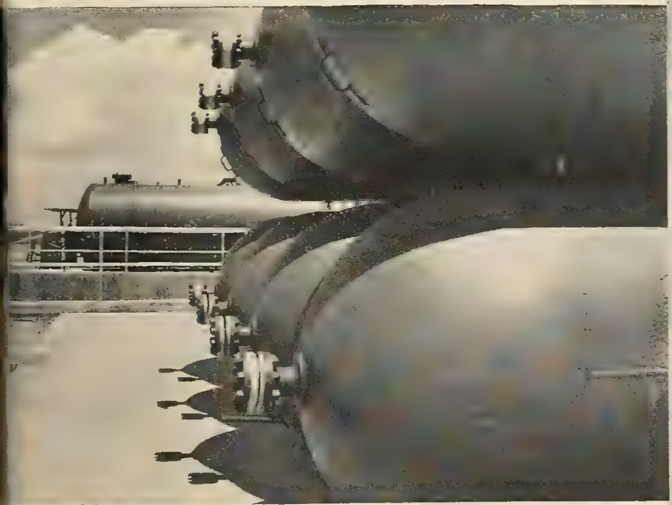

The Atlas is powered by a cluster of liquid propellant rocket engines that burn liquid oxygen and RP-1, a kerosene-like hydrocarbon fuel. 192 pressure tanks fabricated from alloy or Stainless Steel plate at this site store liquid and gases—liquid oxygen and nitrogen and helium gases which are used to inject the fuels into the missiles.

IROQUOIS PACKS SIX SS-11's; by an M/R Correspondent, 12/14/59, p. 29.

NAVY SEEKS ANTI-MISSILE BIRDS; by James Baar, M/R Associate Editor, 12/14/59, p. 40.

MISSILE NEWS IN RECENT PICTURES; 11/9/59, p. 35.

TRIPLE-THREAT TALOS FOR ANTI-AIR, BOMBARDMENT, AICBM; The new Talos will be able to hit planes 100 miles away; Super Talos may be the seaborne defense for U.S. mainland; by James Baar, M/R Associate Editor, 9/21/59, p. 24.

THE ABLE TO DELTA SUCCESS STORY; A history of the progress of the Aerojet-General system from four failures in the Vanguard program to a perfect batting average with Thor-Able, by Frank McGuire, M/R Associate Editor, 8/24/59, p. 22.

REDEYE AND BULLPUP; Bazooka-type missile details released; Martin ASM becomes operational in Atlantic Fleet, by James Baar, M/R Associate Editor, 8/3/59, p. 12.

NAVY'S CORVUS HAS FIRST SUCCESSFUL FLIGHT; 7/27/59, p. 43.

HAWK AND LACROSSE ARE ADDED TO ARMY'S ARSENAL; Artillery units are organized in Texas to train in their use, by M/R Staff, 7/6/59, p. 28.

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AIR FORCE SWINGS BACK INTO SPACE WITH AWARD OF ADVANCED DYNA-SOAR PROGRAM; by James Baar, M/R Associate Editor, 11/16/59, p. 49.

LANDING ACCIDENT TO DELAY X-15 PLANS; 11/16/59, p. 11.

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BACKGROUND ON THE POSTPONED THOR-ABLE PROBE; NASA's planned sun orbiter, Thor-Able IV, could stay within tracking range until May, expanding communication know-how and providing new information on solar system, 12/21/59, p. 17.

EXPLORER VI MAY SOLVE PUZZLE OF REPETITIOUS RADIO SIGNALS; 11/9/59, p. 24.

NEC HEARS REPORTS ON EXPLORERS VI, VII; by an M/R Correspondent, 10/26/59, p. 34.

EXPLORER VII GOES INTO POSSIBLE 20-YEAR ORBIT; 10/19/59, p. 16.

NASA PLANS TO LAUNCH A SATELLITE NEAR VENUS; Thor-Able shot would be trackable beyond 50 million miles and could help restore U.S. prestige, by C. Paul Means, M/R Associate Editor 10/19/59, p. 33.

TRANSIT STILL DUE TO BE FIRST MILITARY SPACE SYSTEM; Despite last month's launching failure, the ARPA-Navy project is proceeding on schedule calling for prototypes in orbit by early 1961; money problems could still bring delays, by James Baar M/R Associate Editor, 10/12/59, p. 16.

VANGUARD CONTRIBUTED GREATLY TO SPACE TECHNOLOGY; The nation's first designed space vehicle was a greater success than failures indicated and its components are used in most newer spacecraft, by C. Paul Means, M/R Associate Editor, 9/28/59, p. 35.

NASA MAY TRY MOON ORBIT IN OCTOBER; Space agency to use Atlas-Able vehicle which was earlier scheduled for Venus probe, by C. Paul Means, M/R Associate Editor, 8/24/59, p. 33.

EXPLORER VI GIVES NASA NEW TRACKING CAPABILITY; Solar-celled power unit slated for deep space probe, 8/17/59, p. 46.

PROJECT TEPEE MAY UNDERCUT NEED FOR BMEWS; 8/17/59, p. 45.

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EVEN WITH GOLD, SCOUT 'POOR'; 12/21/59 p. 18.

VEGA OUT, HOPES PINNED ON CENTAUR; Delay in schedule thought to be primary reason for cancellation and reshuffling; the Air Force's Atlas-Agena will be used as an interim vehicle, by C. Paul Means, M/R Associate Editor, 12/21/59, p. 15.

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SOVIET SUBS BIGGER THREAT THAN ICBM'S; Intelligence reports assume Reds converting to nuclear and deep diving boats armed with Komet III IRBM, Red China now third biggest submarine builder, by James Baar, M/R Associate Editor 8/10/59, p. 32.

TORPEDOES—NEGLECTED FACTOR IN ASW; Between wars we forget about them but they'll have to be vastly more sophisticated and reliable if they are to be equal to their mission in coping with missile submarine threat, by Hal Gettings, M/R Associate Editor, 8/10/59, p. 30.

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General

HOW TO PICK LIQUID TANK MATERIALS; An Army expert outlines how compatibility and strength vary as prime factors, 10/19/59, p. 35.

ICBM FACILITIES WILL COST $550 MILLION IN FY60; An account of requirements in the top U.S. design and construction program, by Lt. Col. Charles B. Alexander, Jr., USAF and Fred E. Ressegieu, 9/21/59, p. 46.

MANAGEMENT—MAJOR SUPPORT PROBLEM; editorial, 9/21/59, p. 122.

SUPPORT MARKET MAY TOTAL $40 BILLION BY 1967; Hardened ICBM bases and Polaris submarines are setting the pace for expansion. A complete forecast for 1960-61, by William E. Howard, M/R Associate Editor, 9/21/59, p. 21.

SOLARIS WILL SALVAGE MISSILES FROM THE DEEP; Low-cost system being developed by Vitro Laboratories should find wide range of uses, including eventual work in charting ocean bottom, by William E. Howard, M/R Associate Editor, 8/31/59, p. 16.

AIR-SUPPORT SPACE PLATFORM ADVOCATED; 8/10/59, p. 36.

MISSILE SUPPORT: THE BIGGER PROBLEMS COMING WITH LARGER VEHICLES; Army Corps of Engineers has the responsibility for solving most of the engineering difficulties ahead, an interview with Maj. Gen. E. C. Itschner, Chief of Engineers, 7/20/59, p. 48.

Launching Facilities

ARGUELLO, PAST, PRESENT AND FUTURE; Details of PMR's Point Arguello facility, including first published pictures, by James Baar and William E. Howard, M/R Associate Editors, 12/28/59, p. 13.

AF, NAVY FIGHT FOR TOP WEST COAST LAUNCHING ROLE; The Air Force wants to use Atlas pads at Vandenberg for polar-orbit launchings which would cross Navy's Pacific Missile Range facility at Point Arguello; Navy is already bothered by Vandenberg's effect on PMR. A special report by James Baar and William E. Howard, M/R Associate Editors, 12/21/59, p. 10.

NAVY PUSHES FOR BIG FLEET OF POLARIS CRUISERS; It urges eventual deployment of hundreds of IRBM's on some 24 cruisers, to supplement subs and SAC; new Polaris surface force might include battleships, by James Baar, M/R Associate Editor, 11/16/59, p. 13.

LAUNCHING—WHERE ICBM'S ARE WEAK; A "mix" of hard, mobile and dispersed sites is needed for protection from enemy missiles; a new "hard" Titan base is being designed, by Warren R. Stumpe, 10/26/59, p. 21.

ARMY ESTABLISHING MISSILE SUPPORT BASE IN FRANCE; by Anthony Vandyk, M/R Geneva Bureau Chief, 9/21/59, p. 81.

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FIBREGLASS WRAPPING LIGHTENS ATLAS: Rocketdyne achieves 25% savings in weight and cost of Atlas thrust chambers, and is developing the technique for use in solid powerplants as well, by Frank G. McGuire, M/R Associate Editor, 12/28/59, p. 18.

FLAME SPRAYER MELTS, DEPOSITS ANY MATERIAL; 12/28/59, p. 24.

PACKAGING INFLUENCES MSE CONCEPTS; "Packs" are boosting reliability and cutting costs, by Edsel F. Moffitt, 9/21/59, p. 49.

NEW IMPETUS IS GIVEN TO DRIVE FOR RELIABILITY; Military services plan to step up use of off-the-shelf components; NASA will stretch out firing schedules in effort to raise its batting average, by Jay Holmes, M/R Associate Editor, 9/14/59, p. 28.

COMPONENTS RELIABILITY: WHAT'S NEEDED?; editorial, 7/13/59, p. 50.

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CURTISS-WRIGHT DEVELOPS AN EXPENDABLE DRONE; by Frank McGuire, M/G Associate Editor, 12/21/59, p. 28.

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PICTURE STORY OF TESTING AT ARDC'S TULLAHOMA WIND TUNNEL FACILITY; 12/21/59, p. 24.

BIG STATIC TEST STAND COMPLETED AT NOTS; 12/7/59, p. 21.

MISSILE MEET TESTS U.S. AIR DEFENSE; Near-combat conditions during William Tell II show at Tyndall AFB show value of weapons mix, but results don't reflect what would happen against real attacking planes carrying electronic counter-measures, by James Baar, M/R Associate Editor, 11/2/59, p. 14.

NAVY SAVES MONEY ON MISSILE TESTS; Weapon's Laboratory's short-cuts in testing and evaluating programs yield economies of millions of dollars and months of development time, by Hal Gettings, M/R Associate Editor, 11/2/59, p. 20.

AUTOMATIC TEST EQUIPMENT SOLVES LOGISTIC NIGHTMARE; Potential market is nearly one-half billion dollars, by George A. Peck, 9/21/59, p. 53.

WHO SHOULD DESIGN AND BUILD TEST STANDS AND GANTRYS? Big steel fabricators dispute role of missile makers in constructing rocket stands, by M/R Staff, 9/21/59, p. 40.

Test Ranges

PMR PLANS TO SPEND $256 MILLION; The nation's largest missile and space vehicle range includes only base from which polar launches can be made, will be heavily used by services and NASA, by M/R Staff, 9/21/59, p. 73.

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MINUTEMAN HANDLING MUST BE DELICATE; by Jay Holmes, M/R Associate Editor, 9/21/59, p. 45.

'ARTICULATION' SOLVES TALOS HANDLING PROBLEMS; High-speed movement from magazine to launching deck is engineered by an articulated rack driving huge hoist, by R. A. Burt, 9/21/59, p. 26.

SUPPORT VEHICLE REQUIREMENTS ARE TRICKY; Experts stress early design to meet complicated needs; a wide variety of vehicle combinations are available, by John J. MacRostie, 7/27/59, p. 17.

TRANSPORTING BIG BOOSTERS BY WATER; Plant-to-pad logistics is essential preliminary design consideration for multimegaton rockets; land and air movement is restricted, 11/16/59, p. 28.

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Isp MAY BE UPPED BY WIRE EXPLOSIONS; Company believes this propulsion method can provide more power than most proposed electrical systems offer; other uses seen in communication, attitude correction, 12/28/59, p. 20.

ION ROCKET SEEN USEFUL FOR SHIFTING ORBITS; NASA experts suggest low-I_{sp} devices for switch from 300-mile to 24-hour level, 10/26/59, p. 19.

ION ROCKETS LEAD IN 'EXOTIC' PROPULSION; Reported at the only open session of Second Symposium on Advanced Propulsion Concepts, jointly sponsored by Avco-Everett Research Laboratory and AF Office of Scientific Research. Papers are abstracted, 10/12/59, p. 28.

COST, HANDLING PROBLEMS KNOCK OUT BORON PROGRAM; Production curtailed after $200 million R&D expense, 8/17/59, p. 48.

ELECTRIC PROPULSION: MUCH THEORETICAL WORK IS STARTED; Although experiments are still in early stages, results so far are encouraging, by Ernst Stuhlinger, 7/20/59, p. 83.

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LINDE DEVELOPS A 'SUPER' INSULATION; Report on a new advance in cryogenic insulating materials, together with a guide to practical comparison of systems, by John F. Judge, M/R Associate Editor, 10/19/59, p. 28.

PRE-COOLING CRYOGENICS TO ELIMINATE COUNTDOWN? Survey of cryogenics support includes suggestion for retractable cooling jacket to prevent boiloff, by James A. Snyder, 9/21/59, p. 35.

NATION'S LIQUID HYDROGEN OUTPUT RISES; Industry-government cooperation is building large tonnage plants for the "ultimate" chemical fuel—until recently a laboratory curiosity, by Jay Holmes, M/R Associate Editor, 8/17/59, p. 21.

CENTAUR ENGINE BEGINS FULL SCALE TESTS; Scheduling calls for P&W to deliver first operational liquid hydrogen engine to Convair in 1960, by C. Paul Means, M/R Associate Editor, 8/3/59, p. 20.

WHERE ARE WE GOING IN FUEL HANDLING? The cryogenic engineer still must be a jack-of-all-trades with industry having to gear up for multi-million pound thrust boosters, by S. David Pursglove, 8/3/59, p. 28.

THE BRIGHT OUTLOOK FOR CRYOGENICS; Other systems are in the works, but the advantages of cryogenics will make them the most efficient for years to come, by Frank G. McGuire, M/R Associate Editor, 7/6/59, p. 21.

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TEMPLE STUDIES HIGH TEMPERATURE FLAMES; A report on the intensive investigations conducted by the university's research institute with a rocket facility which could lead to high-energy breakthroughs, by William L. Doyle, 12/14/59, p. 17.

SERVOVALVES NEED FRESH APPROACH ON TEMPERATURE; Moog Valve believes 1000°F reachable by using acceleration switching servos, by Jay Holmes, M/R Associate Editor, 8/10/59, p. 34.

HOPE SUSTAINS RESEARCH INTO MONOPROPELLANTS; Interest continues despite the strange fuels' many disadvantages; "near-miracle" is hoped for, by S. David Pursglove, 7/27/59, p. 28.

CONTROL, GUIDANCE AND NAVIGATION: PROPULSION IMPOSES DESIGN; Inventiveness is needed most in prime problem areas of components hardware, by S. S. Edwards, W. C. Griffith and J. I. Osborne, 7/20/59, p. 63.

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AEROJET PUSHING HYBRID LIQUID-SOLID ENGINES; 10/26/59, p. 20.

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THE DEMAND FOR NON-PYROTECHNIC IGNITERS; Electric, torch, hot spot, catalytic, and hypergolic systems have many uses in repetitive starts. Part II of a two-part survey, by Frank McGuire, M/R Associate Editor, 10/12/59, p. 20.

IGNITION KEEPS PACE WITH CHALLENGES; Trend is toward hypergolics for restarts and pyrotechnics for single-shots—both may be passed up in future systems. Part I of a two-part series, by Frank McGuire, M/R Associate Editor, 10/5/59, p. 30.

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WILL TITAN SWITCH TO STORABLE FUELS? How the pre-packaged liquid systems concept is profiting from advances in storable fuels and oxidizers; encapsulation techniques may be applicable, by John F. Judge, M/R Associate Editor, 11/16/59, p. 24.

LIQUID ENGINES: EMPHASIS REMAINS ON POWER, SIMPLIFICATION AND RELIABILITY; Cheaper oxygen-jet fuels will be dominant for some time because of tremendous consumption of rockets being designed, by Roy Healy, 7/20/59, p. 53.

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TORPEDOES—NEGLECTED FACTOR IN ASW; Between wars we forget about them but they'll have to be vastly more sophisticated and reliable if they are to be equal to their mission in coping with missile submarine threat, by Hal Gettings, M/R Associate Editor, 8/10/59, p. 30.

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AIR FORCE PUSHES FOR BIG SOLID BOOSTERS; Industry is expecting a decision soon on a feasibility contract for developing a one-million pound thrust rocket, by Jay Holmes, M/R Associate Editor, 11/30/59, p. 21.

SOLID FUEL TECHNOLOGY PROGRESS REPORT; Reliable propellants in operation give I_{sp} ranging from 240 to 250 sec.; new gains occur steadily; ARPA expects 20-30 sec. quantum jump from Project Principia, by Jay Holmes, M/R Associate Editor, 11/2/59, p. 24.

NO FUTURE FOR SOLIDS IN SPACE SHIPS; American Chemical Society hears that solids lack momentum needed for large vehicles. Convention also views advances in plastics, elastomers and polyurethanes, by John F. Judge, M/R Associate Editor, 9/28/59, p. 33.

BETTER METHOD DEVELOPED TO MEASURE SOLID CHANGES; Scientists at Stanford Research Institute have announced the development of an improved method of measuring creep and stress relaxation in solid propellants, by M/R Staff, 9/7/59, p. 15.

DOUBLE-BASE SOLIDS REMAIN STANDARD; Despite inroads by polyurethanes, a major part of the solid-fuel program relies on double-base composition. A report from the Naval Propellant Plant at Indian Head, Md., by Jay Holmes, M/R Associate Editor, 9/7/59, p. 16.

ARPA OBLIGATING $18 MILLION FOR SOLIDS RESEARCH; by Betty Oswald, M/R Associate Editor, 8/3/59, p. 14.

SOLIDS MANUFACTURERS LOOK TO FUTURE WITH CONFIDENCE; With problems being overcome, the role of solid fuels—already important in military applications—is expected to grow greatly, by Frank G. McGuire, M/R Associate Editor, 7/27/59, p. 31.

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SOVIETS LAUNCH AND RECOVER TWO DOGS AND A RABBIT; by M/R Staff, 7/13/59, p. 45.

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SOVIETS PREDICT TWO-COUPLE MOON ORBIT BY SPRING; German newspaper also quotes Red scientists as saying plans call for a two-man earth orbit by the end of this year; moon trip would coincide with Eisenhower visit, 10/26/59, p. 18.

THE FIRST MAN ON THE MOON; editorial, 9/7/59, p. 50.

THE CASE FOR MANNED LUNAR FLIGHT; A pair of NASA officials, speaking for themselves, argue that man can do more at less cost than instruments; they propose detailed plans, 8/31/59, p. 24.

SPACE MEDICINE: NOT KEEPING PACE WITH ENGINEERING; Several new sciences must be developed before man can travel safely through great distances in space, by T. C. Helvey, 7/20/59, p. 68.

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MERCURY NEEDS BASED ON SAFETY; NASA and capsule contractors pick laminated glass fiber and resin for heat shield, nickel cobalt for outside skin, titanium for inner vessel, by C. Paul Means, M/R Associate Editor, 11/23/59, p. 35.

CABIN CONDITIONING SYSTEM WEIGHED; British researchers find air-purifying, oxygen-replenishing system for a man would weigh 55 lbs. for 2 days, 235 lbs. for 10 days, 10/5/59, p. 26.

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'LUNAR SUIT' PROPOSED FOR ASTRONAUTS; Martin Co. design provides environmental controls, communications and sensing equipment for emergencies expected on the moon, 11/16/59, p. 32.

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BOOSTER SCARCITY STALLS SPACE EFFORT; It will be two years before the U.S. can match present Soviet space efforts and it may take many years to catch up, by C. Paul Means, M/R Associate Editor, 12/7/59, p. 30.

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FIBREGLASS WRAPPING LIGHTENS ATLAS; Rocketdyne achieves 25% savings in weight and cost of Atlas thrust chambers, and is developing the technique for use in solid powerplants as well, by Frank G. McGuire, M/R Associate Editor, 12/28/59, p. 18.

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BIG ROCKETS MULTIPLY ENGINE SUPPORT NEEDS; Trend is toward reducing engine sophistication; but man-in-space, new fuels will demand new R&D, by Henry Gilfillan, 9/21/59, p. 28.

ENGINE CONTROLS ARE DEMANDING NEW ART; Environmental demands are running ahead of component improvements; much effort is given to improving servo loops, by Frank G. McGuire, M/R Associate Editor, 8/17/59, p. 23.

CLUSTERING: BIG PAYLOADS QUICKLY; Engines such as Saturn and Nova will add a greater degree of safety and reliability to manned space flight than the comparable single engine boosters, by C. Paul Means, M/R Associate Editor, 8/10/59, p. 21.

TV WATCHES ENGINE CASE TESTS; Newbrook Engine Corp. engineers learn how failure occurs by observing hydrostatic skin tests from safe vantage point, by Jay Holmes, M/R Associate Editor, 8/3/59, p. 15.

CENTAUR ENGINE BEGINS FULL SCALE TESTS; Scheduling calls for P&W to deliver first operational liquid hydrogen engine to Convair in 1960, by C. Paul Means, M/R Associate Editor, 8/3/59, p. 20.

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NOZZLES POSE TOP WEIGHT PROBLEM IN ROCKET MOTORS; Today they account for some 30% of a solid motor's dead weight; varied research effort is aimed at reduction, by M/R Staff, 9/7/59, p. 13.

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TITANIUM INCREASES PAYLOAD; by E. F. Erbin, 11/23/59, p. 61.

TITANIUM, PLASTICS GAIN IN ROCKET CASES; These materials may someday form boosters and second stages, although steel is still tops now because of its low cost and familiarity, by Jay Holmes, M/R Associate Editor, 10/12/59, p. 29.

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ABMA

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ARPA SEEKS 'BLUE SKY' DEFENSE AGAINST RUSSIAN MISSILES; More than $208 million has already been spent or earmarked for Project Defender—the search for something better than Zeus. Last of a two-part series, by James Baar, M/R Associate Editor, 7/13/59, p. 16.

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TIME DRAWS NEAR FOR PAINFUL NIKE-ZEUS DECISION; Cold War strategy will dictate the White House choice of going ahead with the multi-billion-dollar AICBM program, trying to find a cheaper substitute, or doing without anti-missile defense, by James Baar, M/R Associate Editor, 10/26/59, p. 18.

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HAWK AND LACROSSE ARE ADDED TO ARMY'S ARSENAL; Artillery units are organized in Texas to train in their use, by M/R Staff, 7/6/59, p. 28.

NIKE-ZEUS WILL COST $1.5 TO $2 BILLION PLUS IN FY '61; But Administration could decide to kill only anti-missile under development, by James Baar, M/R Associate Editor, 7/6/59, p. 24.

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NASA BRACES FOR FIGHT TO RESTORE HOUSE BUDGET CUTS; Space agency worries over effect on research and Project Mercury but has high hopes Senate will undo the slashes, by C. Paul Means, M/R Associate Editor, 7/13/59, p. 11.

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MISSILE WORK MUSHROOMS IN GREAT LAKES AREA; Electronics in Wisconsin, Minnesota; prime systems and sub-assemblies in Michigan, Ohio, Indiana; support in Illinois. Second of two-part series, by William E. Howard, M/R Associate Editor, 10/19/59, p. 17.

MICHIGAN FIGHTS FOR MISSILE DOLLARS; A state which once was the nation's chief arsenal has fallen out of step in defense work, but motor companies are leading comeback effort. Part I of a two-part survey of the Great Lakes area, by William E. Howard, M/R Associate Editor, 10/12/59, p. 18.

MISSILE/SPACE INDUSTRY PUSHES INTO SAN FERNANDO VALLEY; Electronics, R&D lead the move with construction of industrial parks and campus-like research centers. Second in a series on the Los Angeles area, 9/28/59, p. 12.

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ORANGE COUNTY: NOWHERE TO GO BUT UP! Missile firms have turned the former farming community into the nation's fastest-growing metropolitan area, and the biggest development is yet to come. First of a four-part series on the Los Angeles area, by Frank G. McGuire, 9/7/59, p. 18.

MISSILE/SPACE R&D IS CAPITAL AREAS TOP PRIVATE INDUSTRY; Washington and its environs provide much of the brains behind missile production. Last of a series on the Middle Atlantic Area, by William E. Howard, M/R Associate Editor, 8/31/59, p. 19.

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EAST FIGHTS FOR PRIME MISSILE CONTRACTS; Business amounts to $1 billion a year in New York alone, but there's a dearth of prime contracts. First of a series on the Middle Atlantic States, by William E. Howard, M/R Associate Editor, 8/17/59, p. 17.

USW: A $4-BILLION YEARLY MARKET; Many missile companies are realizing that this great technological challenge is as important as space flight and in the next few years will be just as expensive. Included is a list of market needs, by the M/R Staff, 8/10/59, p. 24.

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BOSTON WORKS TO BECOME THE 'HUB' OF SPACE RESEARCH; Many millions are spent here on missile/space research and production. Second in a series of regional surveys, by William E. Howard, M/R Associate Editor, 7/13/59, p. 12.

NEW ENGLAND'S MISSILE/SPACE MANUFACTURING BOOM; A state-by-state survey shows the Northeast's share of the business is over $1 billion a year, employing more than 150,000 people—and still growing, by William E. Howard, 7/6/59, p. 13.

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NASA: DOD STREAMLINE BOOSTER EFFORT, by C. Paul Means, M/R Associate Editor, 12/14/59, p. 40.

BOOSTER SCARCITY STALLS SPACE EFFORT; it will be two years before the U.S. can match present Soviet space efforts and it may take many years to catch up, by C. Paul Means, M/R Associate Editor, 12/7/59, p. 30.

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NASA WAITS FOR MONEY TO DO ITS OVERALL SPACE JOB; The civilian space agency moves in to the dominant role in U.S. space efforts and will have the engines and vehicles to do the job—if the Administration and Congress provide funds running into billions of dollars, by C. Paul Means, M/R Associate Editor, 11/9/59, p. 12.

SATURN SWITCH TAKES MILITARY OUT OF LUNAR SPACE; Transfer of big rocket to NASA may commit United States to becoming a second class military space power, 11/2/59, p. 12.

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ION ROCKET SEEN USEFUL FOR SHIFTING ORBITS; NASA experts suggest low-I_{sp} devices for switch from 300-mile to 24-hour level, 10/26/59, p. 19.

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NASA SEEKS TO AID SMALL BUSINESSES; Officials of the space agency plan to keep tabs on company capabilities and keep them informed on upcoming contracts, by C. Paul Means, M/R Associate Editor, 7/6/59, p. 26.

NASA WANTS SMALL BUSINESS TO GET ITS SHARE; Civilian agency has good record in letting contracts to small firms and wants more on its buying list, 7/6/59, p. 26.

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NBS STUDIES ELECTRIC ARC AS HIGH-TEMPERATURE SOURCE; 12/21/59, p. 22.

SPACE AGE CONTRIBUTIONS OF BUREAU OF STANDARDS; NBS serves government and industry by providing standards and calibration facilities demanded by extreme requirements of the new technology, by Hal Gettings, M/R Associate Editor, 12/14/59, p. 30.

NBS PRESSES RESEARCH ON DIELECTRICS; a broad study, partly funded by the Pentagon, is aimed at obtaining better measurements and materials, 10/19/59, p. 37.

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AF, NAVY FIGHT FOR TOP WEST COAST LAUNCHING ROLE; The Air Force wants to use Atlas pads at Vandenberg for polar-orbit launchings which would cross Navy's Pacific Missile Range facility at Point Arguello; Navy is already bothered by Vandenberg's effect on PMR. A special report by James Baar and William E. Howard, M/R Associate Editors, 12/21/59, p. 10.

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POLARIS IN 1960; Highlights of final McElroy News session, by Betty Oswald, M/R Associate Editor, 12/7/59, p. 38.

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NAVY PUSHES FOR BIG FLEET OF POLARIS CRUISERS; It urges eventual deployment of hundreds of IRBM's on some 24 cruisers, to supplement subs and SAC; new Polaris surface force might include battleships, by James Baar, M/R Associate Editor, 11/16/59, p. 13.

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HOW THE PENTAGON WILL USE ITS MONEY IN 1960; The year will see the dropping of marginal programs and increasing mergers and consolidations within the industry there will be more spending in some areas, by Betty Oswald, M/R Associate Editor, 12/14/59, p. 15.

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AVCO'S IRVINE MAKES STRONG PLEA FOR UNIFIED COMMAND, 11/9/59, p. 14.

KEEP THE MILITARY IN SPACE ROLE, Editorial, 11/9/59, p. 50.

SATURN SWITCH TAKES MILITARY OUT OF LUNAR SPACE; Transfer of big rocket to NASA may commit United States to becoming a second class military space power, 11/2/59, p. 12.

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ARMY MAY HAVE TO DROP OUT OF SPACE; Shortage of funds and pressure of inter-service rivalry could lead it to leave the space field soon and concentrate on other missions. Third in a series of Pentagon planning, by James Baar, M/R Associate Editor, 8/31/59, p. 11.

AUTHORIZATION 'RIDER' MAY DRAG OUT PROCUREMENT; Defense Department officials fear that additional Congressional testimony may further complicate and slow down contract negotiations, by Betty Oswald, M/R Associate Editor, 8/24/59, p. 32.

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PICK YOUR WAR—THEN PLAN FOR IT; Pentagon's new instruction on industrial readiness planning leaves it up to individual services to choose type of war and make industry gear to match decision, by James Baar, M/R Associate Editor, 8/10/59, p. 16.

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DEFENSE STOCKPILE HITS PEAK, by Heather MacKinnon, M/R Editorial Assistant, 11/23/59, p. 71.

AUTHORIZATION 'RIDER' MAY DRAG OUT PROCUREMENT; Defense Department officials fear that additional Congressional testimony may further complicate and slow down contract negotiations, by Betty Oswald, M/R Associate Editor, 8/24/59, p. 32.

Weapons Systems & Facilities Management

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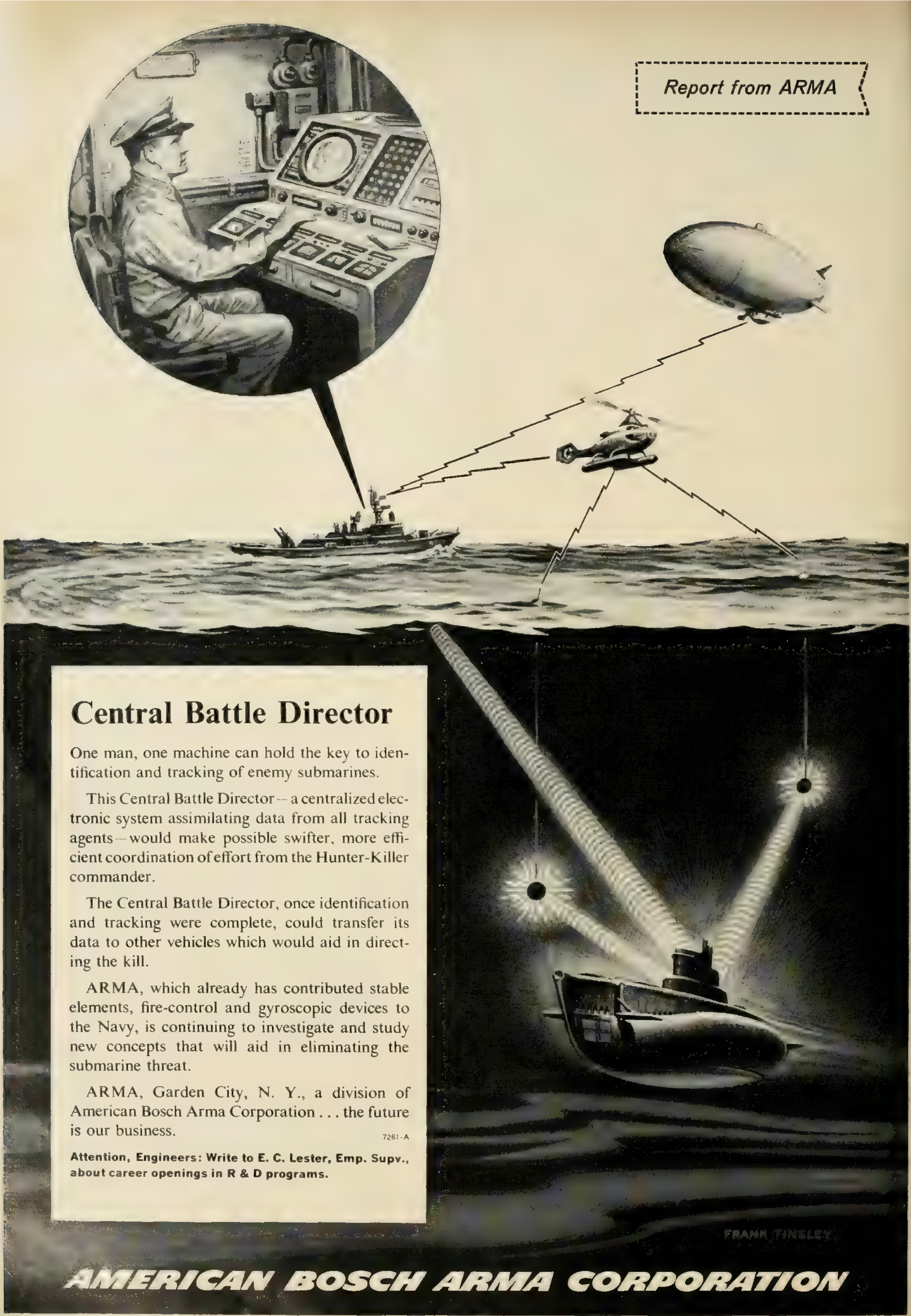
Report from ARMA



Central Battle Director

One man, one machine can hold the key to identification and tracking of enemy submarines.

This Central Battle Director—a centralized electronic system assimilating data from all tracking agents—would make possible swifter, more efficient coordination of effort from the Hunter-Killer commander.

The Central Battle Director, once identification and tracking were complete, could transfer its data to other vehicles which would aid in directing the kill.

ARMA, which already has contributed stable elements, fire-control and gyroscopic devices to the Navy, is continuing to investigate and study new concepts that will aid in eliminating the submarine threat.

ARMA, Garden City, N. Y., a division of American Bosch Arma Corporation . . . the future is our business. 7261-A

Attention, Engineers: Write to E. C. Lester, Emp. Supv., about career openings in R & D programs.

—more about the missile week—

• **Washington**—Sen. Lyndon B. Johnson accused President Eisenhower of failing to provide the leadership necessary to win the space race. The Senate Democratic leader said that unless the President decides immediately to make the U.S. competitive, Congress will have to act in the next session. He said failure to act decisively in space is a "form of unilateral disarmament."

• **Cape Canaveral**—The Air Force successfully tested an *Atlas* Dec. 18 with a "dry engine" start in which water and associated piping was eliminated from the bird as an ignition stabilizing agent. Starting thrust was smaller and the ICBM went full-range—6325 statute miles.

• **Tuscon, Ariz.**—The **Douglas Aircraft**-operated *Thor* IRBM school closed shop after training a total of 1863 Royal Air Force and USAF officers and enlisted men in 19 months. The 1300 RAF trainees are now manning 60 *Thors* (4 squadrons) around the clock at operational sites in Britain.

• **Bristol, Pa.**—An 80-ton "Transrector" for handling rocket engines up to 35 ft. in length, 85 in. in diameter and weighing 80,000 lbs. has been delivered to **Thiokol Chemical Corp.** by **The Siegler Corp.'s** Hufford Division. It is believed to be the largest piece of mobile support equipment of its kind and probably will be used for the first stage of *Minuteman*.

• **Los Angeles**—President Robert S. Bell of **Packard Bell Electronics Corp.** urges establishment of "Q" awards by industry to jack up quality and quantity of U.S. production to win the "war of workmanship." Said Bell, who is establishing the awards in his plants: "we are individually and collectively at war. It is a war against foreign ideology and technology and against our own complacency . . ."

• **Los Angeles**—The BMD's 659th Test Wing, created to back up the Air Force's *Discoverer* satellite program, is expected to take over responsibility for the launch, instrumentation and recovery of AF *Samos* reconnaissance satellites when the program starts next year. This unit would be in addition to—and perhaps conflict with—similar services offered by the Navy's Pacific Missile Range (M/R, Dec. 14, p. 10). *Samos* will be launched from Point Arguello, Calif., primary facility of the PMR.

• **Bethpage, N.Y.**—Grumman Aircraft Engineering Corp. is making a three-month study of the feasibility of using nuclear propulsion to extend the range of a low level attack missile. The study is at Grumman's initiative under a $1-a-year contract with the Bureau of Naval Weapons. Walter Scott, Grumman Chief of Preliminary Design, said his group has been studying application of reactors to ramjets for about a year.

• **Washington**—The electronics industry share of the military hardware market rose to $4.5 billion in 1959, 33% of the total, despite a general leveling off of total defense procurement. The figure is expected to increase fairly substantially next year, Electronic Industries Association said in a year-end statement. Hardware for non-military space applications approached $100 million in 1959. EIA reported overall electronics sales of $9.2 billion in 1959, projected $10.35 billion for 1960, and forecast $20 billion a year by 1970.

NASA Launches *Javelin* To Measure Galactic Noise

WALLOPS ISLAND, VA.—The National Aeronautics and Space Administration on Dec. 22 launched a four-stage *Javelin* sounding rocket to an altitude of 560 miles to measure the intensity of galactic noise.

NASA scientists also hoped that the launch would determine how well the fourth-stage *X-248* rocket would perform in a vacuum.

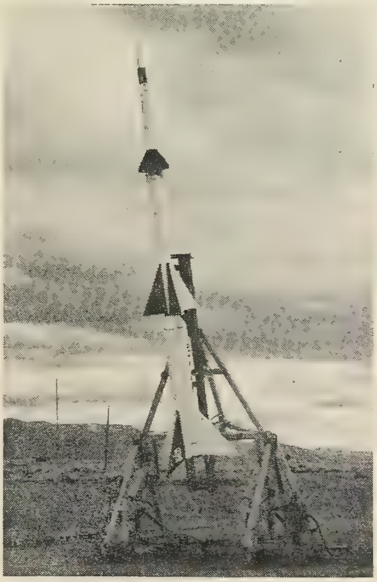
The rocket's 480-pound payload contained a three-megacycle radio receiver which telemetered galactic radio signals back to earth. Because galactic noises are absorbed by the ionosphere, it is necessary to measure them when they are encountered at altitudes above 450 miles.

Data on the performance of the *X-248* rocket was telemetered to stations located at Wallops, Cape Hatteras, and Cape Canaveral.

The *Javelin* is a combination of an *Honest John*, two *Nikes*, and the *X-248*. Its weight at takeoff was approximately 7000 pounds.

The payload came down in the Atlantic Ocean about 600 miles from Wallops Island.

Record Breaker—



THREE-STAGE missile built by Curtiss-Wright for tests in Boeing's *Dyna-Soar* program hit 6000 mph in Dec. 16 firing at Holloman AFB—new high for ground launch.

Million-lb.-thrust Booster Project Reported Under Way

LOS ANGELES—**United Research Corp.** reportedly has begun a project to build a one-million-pound-thrust solid propellant booster with its own funds.

Reliable sources said the company will complete the project relatively quickly, to have the booster ready when a requirement is established.

Questioned by M/R, company officials said they were "not at liberty to discuss the report," but did not deny it.

Vacuum Cadmium Plating Process Is Made Available

NEWTON, MASS.—Custom vacuum cadmium plating services are now available in the East and Midwest.

NRC Equipment Corp., developer of the process, says **Poly-Kote, Inc.**, North Attleboro, Mass., and **Electro-Vac Division** of **Radio Cores, Inc.**, Melrose Park, Ill., are now authorized to use it.

The process makes it possible to protect high-tensile steel missile parts against corrosion without subjecting them to hydrogen embrittlement.

SAC Receives Its First *Hound Dog*

DOWNEY, CALIF.—Gen. Thomas S. Power, Commanding General, Strategic Air Command, took delivery of the first production model of **North American Aviation's** GAM-77 *Hound Dog* air-to-surface missile at the company's missile division here.

General Power said the *Hound Dog*, slated to become operational with SAC by next spring, is a megaton class weapon and can carry the H-bomb. "Its accuracy is measured in feet rather than the usual accuracy of missiles which is measured in miles," he added.

SAC's basic requirement for the *Hound Dog*, which will be used in **Boeing** B-52G aircraft, is to enhance the capacity of its manned bombers, General Power said.

He pointed out that the *Hound Dog* will be used to attack enemy defenses by launching it beyond the range of early warning radar, but he declined to discuss the missile's range other than to say that it was "several hundred" miles. The *Hound Dog's* **Autonetics**-produced inertial autonavigation system is said to be immune to enemy decoying or jamming. It is also possible for the B-52 navigator to select missile cruise altitude to target or change the target after the missile is airborne.

Additional advantages of the missile were noted. The J-52 engine can provide the mother ship with additional thrust and its inertial guidance system can be used to supplement the bomber's navigational equipment.

The B-52 can carry two *Hound Dogs* in addition to its H-bomb warload.

NAA's Missile Division was awarded an R&D contract for *Hound Dog* in August 1957. Initial production contract was announced in November, 1958. First powered flight of the missile was in April, 1959. The missile is currently undergoing flight testing at Eglin AFB, Fla.

General Power told a press conference in Los Angeles that "There is a definite requirement for the B-70 as a successor for the B-52." He said also that he expects there will be sufficient money in the new defense budget for development of the *ALBM* (air-launched ballistic missile). *Hound Dog* also is "adequately funded," he added.

Third Test for Nike-Zeus

EARLY TEST model of *Nike-Zeus* anti-missile missile, of this type, was fired by Army at White Sands Missile Range, N.M., on Dec. 16. First stage fired properly, and second stage separated, but second-stage sustainer motor apparently did not ignite.

NASA Boosts Spending For *Mercury* Tracking

WASHINGTON—A report released by the Senate Space Committee last week reveals that NASA will spend $31.4 million more than originally planned for the Project *Mercury* world-wide tracking network in Fiscal 1959-60.

Present indications are that the network's total cost will be somewhere around $75-80 million—about $50 million more than was estimated in the winning bid.

NASA came up with the extra $31.4 million, according to the report, by transferring $15 million from Project *Mercury* R&D funds, and by finding $16.4 million elsewhere in the space agency's tight budget.

Three major reasons given by informed sources for the increased cost are rising prices, unrealistic initial estimates, and expansion of the network.

Principal expansion was the addition of a tracking station to be built in Central America, which gives the network the capability of bringing the manned capsule down after only one orbit.

According to a recent speech by NASA General Counsel John A. Johnson, total cost of the *Mercury* program has now increased from the original estimate of $250 million to $350 million.

The space administration is expected to make up some of this shortage in the Fiscal 1961 budget.

Underfunding and time lags reportedly have already delayed the *Mercury* program until 1962. Further delays could create an age problem which could eliminate the older astronauts now training under the program.

contracts

NASA

$175,000—**Donner Scientific Co.**, Concord, Calif., for production of an altitude sensor, accelerometers and accelerometer switches for use in Project *Mercury*. Subcontract from **McDonnell Aircraft.**

NAVY

$4,000,000—**Hazeltine Corp.**, Little Neck, N.Y., for 32,000 sonobuoys and repair kits.

$3,335,533—**General Electric's** Light Military Electronics Dept., for sonobuoys.

$500,000—**Solar Aircraft Co.**, for research, development and production of a new lightweight rocket nozzle and rocket motor cases for the *Polaris* missile. Subcontract from **Aerojet-General Corp.**

AIR FORCE

$5,000,000—**Worthington Corp.**, Harrison, N.J., for air conditioning, diesel engines, generators, compressors and a wide range of instrumentation equipment for the *Titan* bases being built near Denver.

$78,976—**Aero-Test Equipment Co., Inc.**, Dallas, for low-pressure high-altitude test chamber (six-man capacity) plus spare parts and reproducible copy.

$65,985—**Kearfott Co. Inc.**, Little Falls, N.J., for 543 three-inch repeater indicators to be used in airborne weather radar systems.

$59,740—**Dynamic Research, Inc.**, Los Angeles, for nitrogen recharger for use in nitrogen conversion system in support of the *133A* program.

$59,505—**California Institute of Technology**, Pasadena, for research on "Growth of Boundary Layers in Plasma Accelerators."

$45,915—**University of Minnesota**, Minneapolis, for research on "Microwave Studies of Semiconductor Crystals."

$40,646—**Beckman & Whitley, Inc.**, San Carlos, Calif., for synchronized framing camera with control units and turbine.

$40,310—**Radiation, Inc.**, Melbourne, Fla., for non-personal modification and repair PCM data handling equipment on *Minuteman* project.

$36,600—**University of California**, Berkeley, for continuation of research on "Effects of Internal Stress and Microstructures on the Physical Properties of Model Ceramic Systems."

$36,100—**University of Maryland**, College Park, for continuation of research on "Foundations of Scattering Theory and Applications to Physical Problems."

$33,139—**Collins Radio Co.**, Dallas, for spare replacement modules for microwave system.

$25,200—**Sanborn Co.**, Waltham, Mass., for hot wire recorder and recorder system for use in support of Project *WS-133A*.

$25,125—**Northrop Corp., Norair Div.**, Hawthorne, Calif., for reproducible copy applicable to *SM62A*.

$25,000—**Ohio State University Research Foundation**, Columbus, for research on "Magnetic Resonance and Spin Relaxation of Ions in Solution, Complex Molecules and Free Radicals."

ARMY

$8,911,904—**Radio Corp. of America** for improved missile measurement equipment for a missile tracking ship.

$3,765,417—**Raytheon Co.**, Waltham, Mass., for engineering services for the *Hawk* missile system.

$984,279—**Raytheon Co.**, for engineering services in connection with the *Hawk* missile.

$876,927—**Raytheon Co.**, for *Hawk* missile repair parts.

$825,000—California Institute of Technology, Pasadena, for research and development re guided missiles.

$423,794—**Nichols-Southern Div. Luba Consolidated Industries, Inc.**, Baton Rouge, La., for construction of propellant inspection building for *Minuteman*.

$400,000—**Atlantic Research Corp.**, Alexandria, Va., for developing an anti-aircraft guided missile known as *Redeye*.

$225,000—**Sperry Rand Corp.**, Sperry Utah Engineering Laboratory Div., for repair parts for *Sergeant* guided missile system.

$129,836—**AiResearch Manufacturing Co.**, Los Angeles, for *Nike-Hercules* replenishment repair parts.

$129,561—**Douglas Aircraft Co. Inc.**, Santa Monica, for field change kits and repair parts.

$126,167—**Raytheon Co.**, for services for production engineering of shroud, fin and windshield for XM-28 and XM-29.

$117,610—**Lockheed Missiles & Space Div.**, for basic research on a new technique for harnessing solar energy.

$99,625—**Continental Technical Services, Inc.**, for services in connection with design, development and testing of rocket motors, airframes, launchers, guidance systems and related equipment.

$96,064—**Douglas Aircraft Co., Inc.**, Santa Monica, for repair parts for *Nike* system.

$94,958—**General Electric Co.**, Pittsfield, Mass., for development of a cryogenic gyro.

$65,292—**Texas Instruments, Inc., Semi-conductor Div.**, for solar cells and assemblies.

$63,175—**Hoover Awning and Manufacturing Co.**, Miami, for radome cover.

$47,660—**Texas Instrument, Inc.**, Dallas, for unmounted silicon solar cells.

$46,556—**Permanent Filter Corp.**, for *Nike* repair parts.

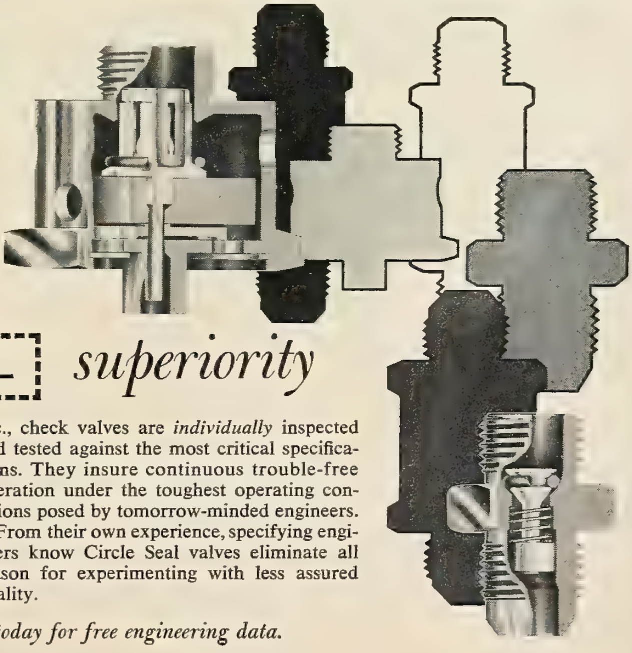
$42,361—Research Institute of Temple University, Philadelphia, Pa., for development and fabrication of a liquid propellant evaluator.

$40,740—**Western Electric Co.**, New York City, for *Nike* spare parts and components.

$29,989—**Townsend Engineered Products**, Santa Ana, Calif., for design and development of a suppression kit.

$27,793—**Stanford Research Institute**, Menlo Park, Calif., for measurement of radioactive isomers produced by gamma rays.

$27,278—**General Electric Co., Defense Div.**, Light Military Electronics Dept., for research and development on thermocouple energy converters.



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FELD

Sheldon L. Feld has been named applications engineer at Yardney Electric Corp., manufacturers of silvercel and silcad batteries. With the firm since 1956, Feld was formerly a project engineer in design and development. Prior to joining Yardney he was associated with the Dexter Chemical Corp. and Charles Pfizer, Inc.

VAN RENNES

United Research Inc., has announced the election of **Dr. A. B. Van Rennes** as vice president in charge of its technical division. Among his responsibilities will be direction of fundamental research and development programs in instrumentation, including programs for the measurement of meteorological variables and fuel contamination.

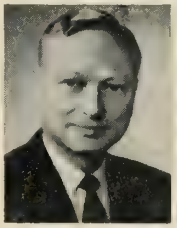
Dr. Van Rennes comes to United from the research laboratories division of Bendix Aviation Corp., where he was supervisor of the nuclear technology group.

During the past eight years, Dr. Van Rennes has been a consultant to various industrial and government groups, and has published a variety of papers on nuclear instrumentation techniques and on nuclear reactor kinetics, control and instrumentation.

PETERSON

Rear Adm. Mell A. Peterson (USN ret.), formerly commander of the Naval Ordnance Laboratory, Silver Spring, Md., has been named executive vice president and a director of Bulova Research & Development Laboratories, Inc. In the Navy for 29 years, Peterson specialized in research and development administration and industrial control.

Rear Adm. A. B. Metsger (USN ret.), has been appointed assistant to the president of The Marquardt Corp. He will help to plan and coordinate the company's technical efforts aimed toward application of Marquardt's capabilities and facilities to new products and services.



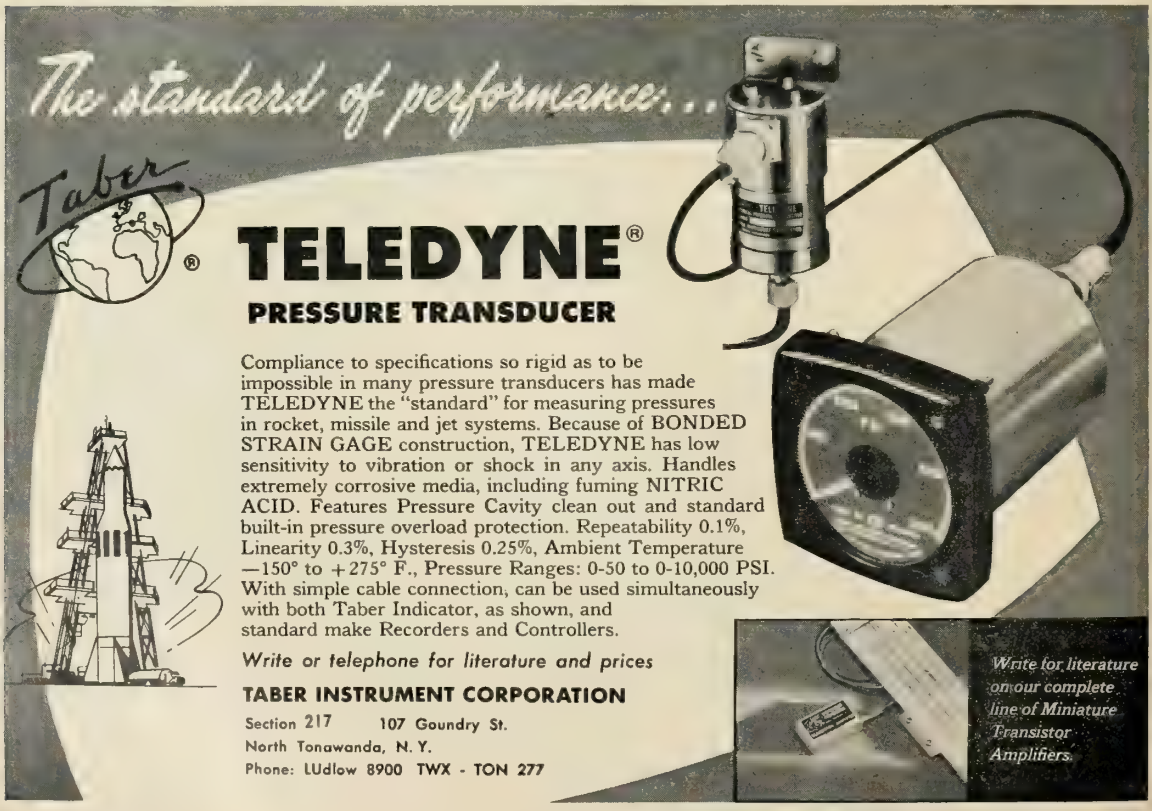
METSGER

During his 28 years of active service, Metsger served as deputy chief of Naval Research from 1956 to 1959, and was director of the Guided Missiles Division of the Bureau of Aeronautics from 1952 to 1956. He also headed the fighter branch of BuAer and managed more than 12 major jet fighter development programs. And he was responsible for initiating the Fleet Ballistic Missile Program, now *Polaris*.

Reuben Thorson and **John P. Gallagher** have been elected directors of The Hallicrafters Co., electronics development and manufacturing firm.

Thorson is general partner and chairman of the policy committee of Paine, Webber, Jackson & Curtis, investment brokers. He is also a director of Growth Industry Shares, Inc., Wilson-Jones Co., Illinois Mid-Continent Life Insurance Co., Booth Fisheries Corp. and United Electric Coal Co.

Gallagher is a partner and member of



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the executive committee of Booz, Allen & Hamilton, and is the coordinating partner of the firm's central region.

Analab Instrument Corp. has announced the appointments of **Theodore Lasar, Philip G. Schifflin** and **Edwin J. Sommers** as senior engineers.

Lasar formerly was a senior engineer with Allen B. Du Mont Laboratories. Prior to that he was with the Weston Electrical Corp. and Bendix Aviation Co.

Schifflin formerly was a research administration coordinator with Du Mont Laboratories, where he directed the operations of the commercial engineering department model shop and was a production engineer in the research and development department engaged in missile test equipment.

Sommers, responsible for the mechanical design engineering, was formerly with Emerson Radio and Phonograph Co. as a senior engineer. Earlier he was with Western Electric Co., engaged in test equipment design.

Alfred Sansonetti has been named to the newly created post of vice president-manufacturing for Avien, Inc., designer and manufacturer of instrumentation systems in temperature control, fluid flow measurement, automatic checkout equipment and propulsion system instrumentation. He was formerly manager of the company.

Before he joined the firm in 1956, Sansonetti was assistant general manager of Airborne Accessories Corp. and was also associated with the General Electric Co.

Douglas Aircraft Co. has announced the appointment of **Edward F. Spraitz** as assistant Washington representative for space programs. He will coordinate company space activities with all government agencies. He has been a member of the Washington office for the past three years.

Before coming to Douglas, Spraitz held key engineering posts with the National Bureau of Standards and the Naval Ordnance Laboratory.

Roylyn Inc., manufacturer of aircraft, missile and industrial components and quick disconnect couplings, has announced appointment of **Richard B. Hubbard** as vice president, and of **Benjamin N. Ohannesian** as production manager. In addition, Hubbard has been elected to the board of directors.

Hubbard formerly was affiliated with Pacific Airmotive Corp. as vice president and assistant to the president; with ACF Industries as president of its Erco division; with Specialties, Inc., as vice president.

Ohannesian was previously with Clary Dynamics where he served as supervisor of production and material control, works manager of the aircraft division, operations manager of the automatic controls division and director of manufacturing.

Joseph H. Hannigan, formerly sales engineer with The Gabriel Co., has been chosen director of radar and infrared communications, technical liaison division of The National Co. Inc.

Hannigan comes to National with a number of years' engineering experience including planning, designing and installation of countermeasures, guided missile radar control, remote control equipment, radiation warning systems, and infrared devices. He was also a consultant in nuclear power instrumentation and control.

John F. Probst has been elected president of South Bend Lathe, Inc., a subsidiary of American Steel Foundries, succeeding **Russel E. Frushour** who is retiring. Frushour, president of the company since 1939, will remain a director as well as a consultant.

Probst joined South Bend in 1946, was elected assistant vice president in 1955, and vice president in 1959. He is also a director of the company.

Richard S. Anderson will become secretary-treasurer, replacing **Maurice Howard,** who is retiring.

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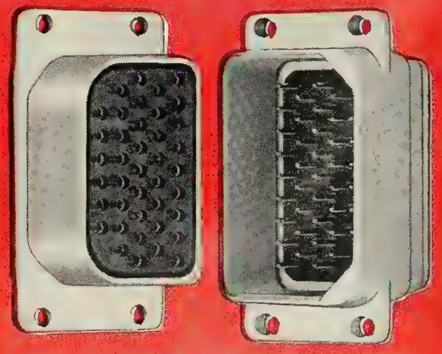

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Public Be Blamed

To the Editor:

In your Dec. 7 editorial, you state that there are indications that the public does not agree with the Administration's lack of concern (over losing the space race). I am wondering if this is truly a "lack of concern" or just pondering over how to get the public's support and/or how "loose" the strings should be *if* the money were appropriated, and at the expense of what.

The public has been lulled into a state of apathy for the last 25 years, with the politicians promising Mr. John Q anything he wants for his vote. Mr. John Q now wants to have his cake and eat it too. The labor unions, operating on the same basis, insist that their members have a sizeable raise every year. Much money appropriated has been literally dumped in the river . . .

So, I am wondering just who is to blame. I believe it's the public themselves—for permitting themselves to be lulled into apathy in the first place; secondly, for voting for politicans who had nothing to offer except a promise to the people to "give" them anything they "wanted"; and finally, for demanding—or maybe I should say refusing to give up—certain wartime spending for fear they might have to tighten their belts for a few months. It is a well known fact that when an air base or a defense plant is to be closed the people start clamoring and write their Congressmen, the pressure starts—and soon the plant is not only kept open but expanded. Small bureaus are built up within local, state and federal governments, and many defense business contractors—whose survival depends entirely, or nearly so, on government defense contracts that are almost entirely wasteful and cost billions of tax money.

. . . I hardly believe Los Angeles would be a fair poll of the U.S.A. (concern over losses in the space race). Even if it were, I would be willing to bet 10 to 1 that if wages were frozen and taxes raised $50 per person you would lose 4 out of 5 of your votes . . .

K. U. Benjamin
Shelley Electric Inc.
P. O. Box 2239
Wichita 1. Kan.

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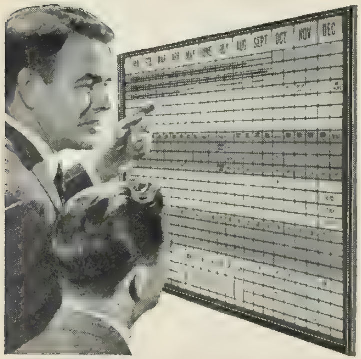

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Anti-Second Law

To the Editor:

I read with considerable interest the article in the Nov. 16 M/R concerning 182% thermal efficiencies.

Some years ago I submitted a group of papers to various Washington agencies concerning energy, matter, and *anti-second law devices.* The only reply I could evoke from these worthies was much laughter. It is refreshing, therefore, to see in print the idea that "basic truths" might need to be re-examined. Several years ago the term "anti-second law" was in the same classification as certain four-letter words. I am sure that in the future the term will become quite respectable.

Without doubt the Russian device is merely a heat pump, but the next device, or the one after that, may indeed exceed second-law efficiencies. The Russians certainly have shown enough imagination to make this possible.

Robert E. Span
Registered Engineer
P.O. Box 157
Ligonier, Pa.

U.S. Bonds for Space?

To the Editor:

Regarding your editorial of Dec. 7 about public concern over the U.S. space effort, may I quote from your Nov. 30 issue ("Who Says There's A Space Race?"): "The space program costs less than ten dollars per year per U.S. adult or roughly one evening's entertainment per year."

Why not government SPACE BONDS in various denominations to allow U.S. citizens so disposed to contribute one or two "evenings' entertainment per year" to their country's *bigger space effort?*

Arthur A. Wiese
753 Utah St.
Toledo 5, Ohio

ATOMIC RADIATION, part II. RCA Service Company, a division of the Radio Corp. of America. Order from Government Services (210-1), RCA Service Company, Camden 8, N.J. 110 pp. $2.65.

The practical aspects of radiation protection is covered in a book intended primarily as a practical guide for industrial, military, and research installations engaged in nuclear energy activities.

Discussed are such subjects as monitoring techniques and instruments, radiation exposure control, decontamination, radioactive material transport and waste disposal.

SHORTWAVE PROPAGATION, Stanley Leinwoll. John F. Rider Publisher Inc. 160 pp. $3.90.

This book presents the basic principles of shortwave radio propagation, and how it is used in long distance radio communication.

Following the exploration of basic phenomena, the author deals with ionospheric variations attributable to sunspot cycles as well as abnormal causes which have so often disrupted man's ability to communicate by electro-magnetic waves. He explains the preparation of maximum usable frequency (MUF) charts and how to use them.

A chapter is devoted to the explanation of the correlation between the seasons and the most satisfactory frequency within the 3 to 30 mc range which are usable for interglobal communication.

The book is suited to the radio amateur who is concerned with global communication on shortwaves. It is also recommended to Armed Forces users of the radio-frequency spectrum.

ENERGY DISSIPATION BY FAST ELECTRONS, L. V. Spencer, National Bureau of Standards. Order from Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. 70 pp. $.45.

Presented is one of a series of reports on radiation physics data being prepared with the support of the Office of Naval Research and the Atomic Energy Commission. Tabulations are given of the energy dissipated by fast electrons at different distances from monoenergetic electron sources, for plane perpendicular and point isotropic sources.

Tabulations are designed to answer the following type of problem: If electrons of kinetic energy E_o are produced at a point or on a plane in a material with atomic number Z, the electrons will travel away from their point of origin, dissipating energy to the material as they go. When each electron has given up its initial energy, what is the spatial distribution of the energy transferred to the surrounding material?

Results are given for E_o, varying in approximately logarithmic intervals from 0.025 to 10 Mev, for carbon, aluminum, copper, tin, lead, air, and polystyrene.

—when and where

DECEMBER

American Chemical Society, Industrial and Engineering Chemistry Division, 1959 Christmas Symposiums on "Mechanisms of Inter facial Reaction," Shriver Hall, Johns Hopkins University, Baltimore, Dec. 28-29.

JANUARY

Gas Dynamics, Colloquium, Electrostatic Propulsion, University of Michigan, Jan. 7.

Sixth National Symposium on Reliability and Quality Control in Electronics IRE, EIA, AIEE, ASQC, Statler-Hilton Hotel, Washington, D.C., Jan. 11-13.

First International Space Science Symposium, and COSPAR Plenary Session, sponsored by COSPAR, Nice, France, Jan. 11-16.

Society of Plastics Engineers, 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago, Jan. 12-16.

Gas Dynamics Colloquium, Shock Tube Research, University of Michigan, Ann Arbor, Jan. 14.

American Astronautical Society, Sixth Annual Meeting, Statler-Hilton Hotel, New York City, Jan. 18-21.

American Management Association, Special Research and Development Conference, "Capitalizing on Technology," Roosevelt Hotel, New York City, Jan. 20-22.

Gas Dynamics Colloquium, Structure of Strong Normal Shockwaves, Northwestern University, Evanston, Ill., Jan. 21.

Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York City, Jan. 25-28.

Second Annual Symposium on High Speed Testing, sponsored by Plas-Tech Equipment Corporation, Somerset Hotel, Boston, Jan. 27.

Gas Dynamics Colloquium, Research in Rarified Gas Dynamics, Northwestern University, Jan. 28.

Seventh Annual Western Spectroscopy Conference, Asilomar, Pacific Grove, Calif., Jan. 28-29.

Amercan Rocket Society, Solid Propellants Conference, Princeton University, Princeton, N.J., Jan. 28-29.

FEBRUARY

Chemical Institute of Canada, Toronto Section, Symposium on Gas Chromatography, Seaway Hotel, Toronto, Ont., Feb. 1.

Instrument Society of America, Houston Section, Instrument-Automation Conferences & Exhibit, Rice Hotel & Sam Houston Coliseum, Houston, Feb. 1-4.

Sixth Annual Midwest Welding Conference, sponsored by Armour Research Foundation of Illinois, Institute of Technology; Chicago Section, American Welding Society, Illinois Tech Chemistry Bldg., Chicago, Feb. 3-4.

Institute of Radio Engineers, Professional Group on Military Electronics, Biltmore Hotel, Los Angeles, Feb. 3-5.

Seventh Annual Solid-State Circuits Conference, sponsored by Institute of Radio Engineers, American Institute of Electrical Engineers, University of Pennsylvania, Philadelphia, Feb. 10-12.

First National Symposium on Nondestructive Testing of Aircraft and Missile Components, sponsored by Southwest Section, Society for Nondestructive Testing; Southwest Research Institute, Hilton Hotel, San Antonio, Tex., Feb. 16-18.

AIEE Symposium on Engineering Aspects of Magnetohydrodynamics, University of Pennsylvania, Philadelphia, Feb. 18-19.

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By combining optics, mechanics and frequently electronics, Kollmorgen designs many different types of instruments and systems for industrial and defense viewing and inspection applications. A new illustrated brochure describes our design and manufacturing facilities and primary fields of interest. For your copy, write Dept. 10D.

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Anybody Want a Moral Victory?

NASA maintains that the U.S. space program has produced more scientific results than the Russian program, that the Soviet achievements were simply more spectacular.

This seems a little like the old business of claiming a moral victory for the home team because it played a clean game while the opposition got a little rough and won 54 to 3.

We would feel somewhat better about this kind of rationalization if we could see a clear pattern in the American program; if some one person in authority (and who is in authority?) would say:

"This is what we want to do and this is how we are going to do it."

If we would lay out a program of desired achievements—and back it up with enough money and merchandise to insure that one mishap or one miscalculation does not bring the program to a halt and make us look foolish in the eyes of the world.

Such a program might make us, the country and the world more inclined to believe, as NASA declares, that our way is best; that in the long run we will push forward over a broad front; that the space satellites and spacecraft of the 1970's and '80's will carry more American than Soviet flags.

At the moment we are not convinced. Neither, we fear, are the American people or the world.

Let the People Know

While NASA is organizing its command for an assault on the broad front of the space program, as it says, we think it might be a good idea if NASA officials would explain to the public—as they must explain to Congress very shortly—the reason for two big space boosters which will materialize at about the same time.

Project *Saturn* is the clustering of eight Rocketdyne engines to produce 1½ millions pounds of thrust. Slipping badly from lack of money, the *Saturn* will probably be fired in 1963, come to full strength in 1964.

Simultaneously, Rocketdyne is perfecting a single rocket engine of 1½ million pounds thrust (the F-1) which is due to become operational at about the same time.

By naming Maj. Gen. Don Ostrander, USAF, as head of the NASA booster program and placing him in charge of the Von Braun group at ABMA, NASA has in effect put the *Saturn* and the F-1 programs in the same workshop.

A great many knowledgeable people in the space field question the necessity of both the *Saturn* and the F-1 programs; specifically, they question the necessity of the *Saturn,* which has been variously described as a great white hope and as a big clinker.

They speculate: is the billion-dollar *Saturn* continued as a back-up for the F-1? Is it a parallel program for different purposes? Is it an exercise to give us experience in clustering engines because we will eventually want to cluster the F-1 into a 6-8-million-pound-thrust *Nova*? Is it just something to keep the ABMA team busy for a while?

NASA must have its reasons for both programs. We strongly believe that they should be presented to the public even before they are spelled out in great detail to answer the searching questions of Congress.

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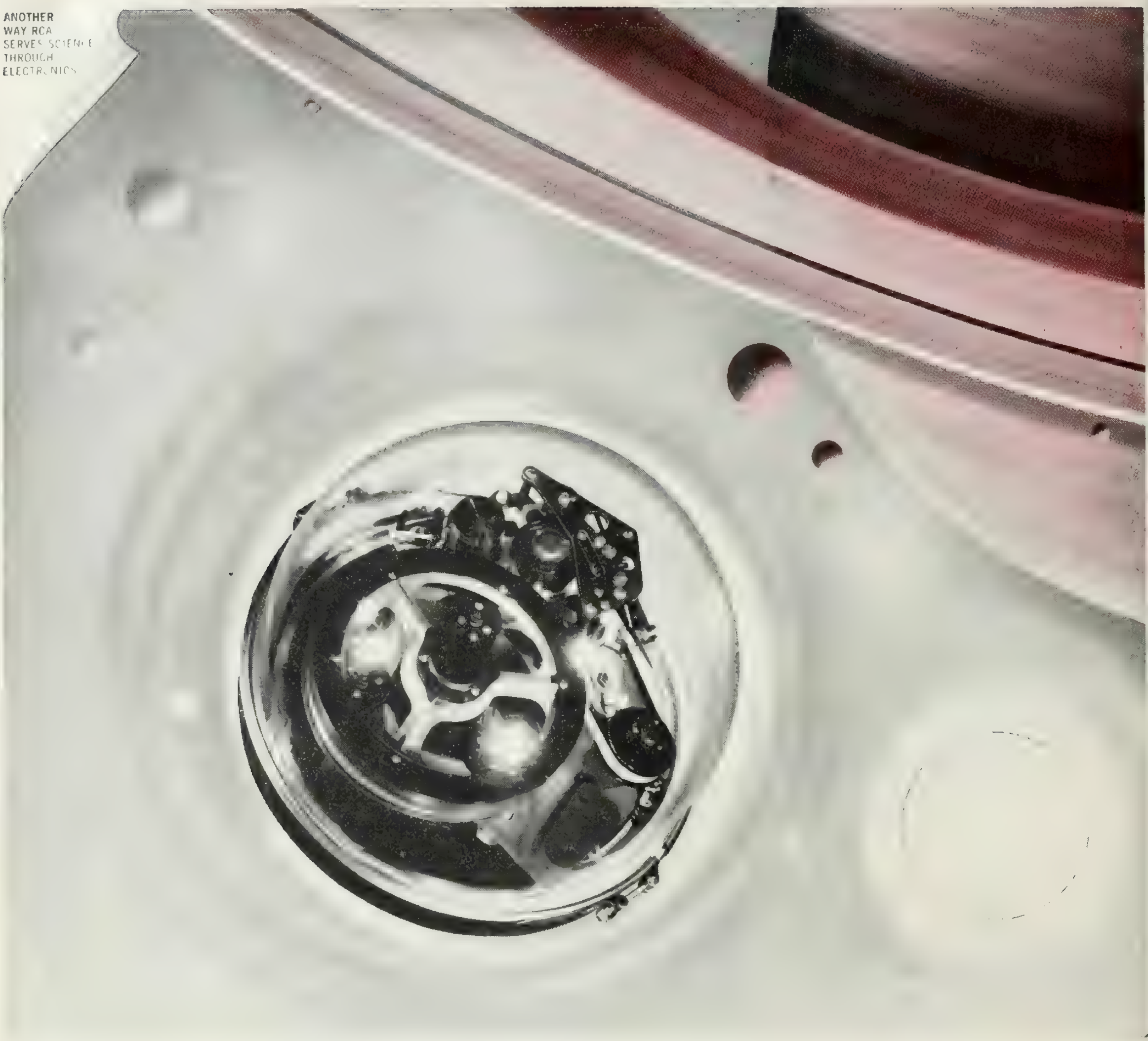

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Systems Development for Space Technology:

Magnetic Tape Recorders

Develop a tape recorder capable of handling video signals, but light and compact enough to fit in a satellite. Design for minimum power drain. Make the unit rugged to stand up under launching stresses and operate unattended for the life of the satellite.

From requirements such as these, Astro-Electronic Products Division developed the video tape recorder pictured above.

The entire unit, including electronic circuits, weighs less than nine pounds. It is designed to accept video signals from a satellite TV camera and deliver at its output a frequency-modulated carrier suitable for input to a transmitter. Weight and power drain in the tape transport are reduced without sacrificing tape motion stability. Normal braking methods are eliminated in favor of a constant-tension spring coupling between reels which keeps tape tension constant. The entire system is designed to operate normally in the vacuum of space.

Video or digital data tape recorders are typical of the many specialized systems developed at AEP to spearhead man's advance into space. Whether your problems involve electronic instruments, mechanical sub-systems, entire satellite systems, or the supporting ground control equipment, AEP can help you find the answer.

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